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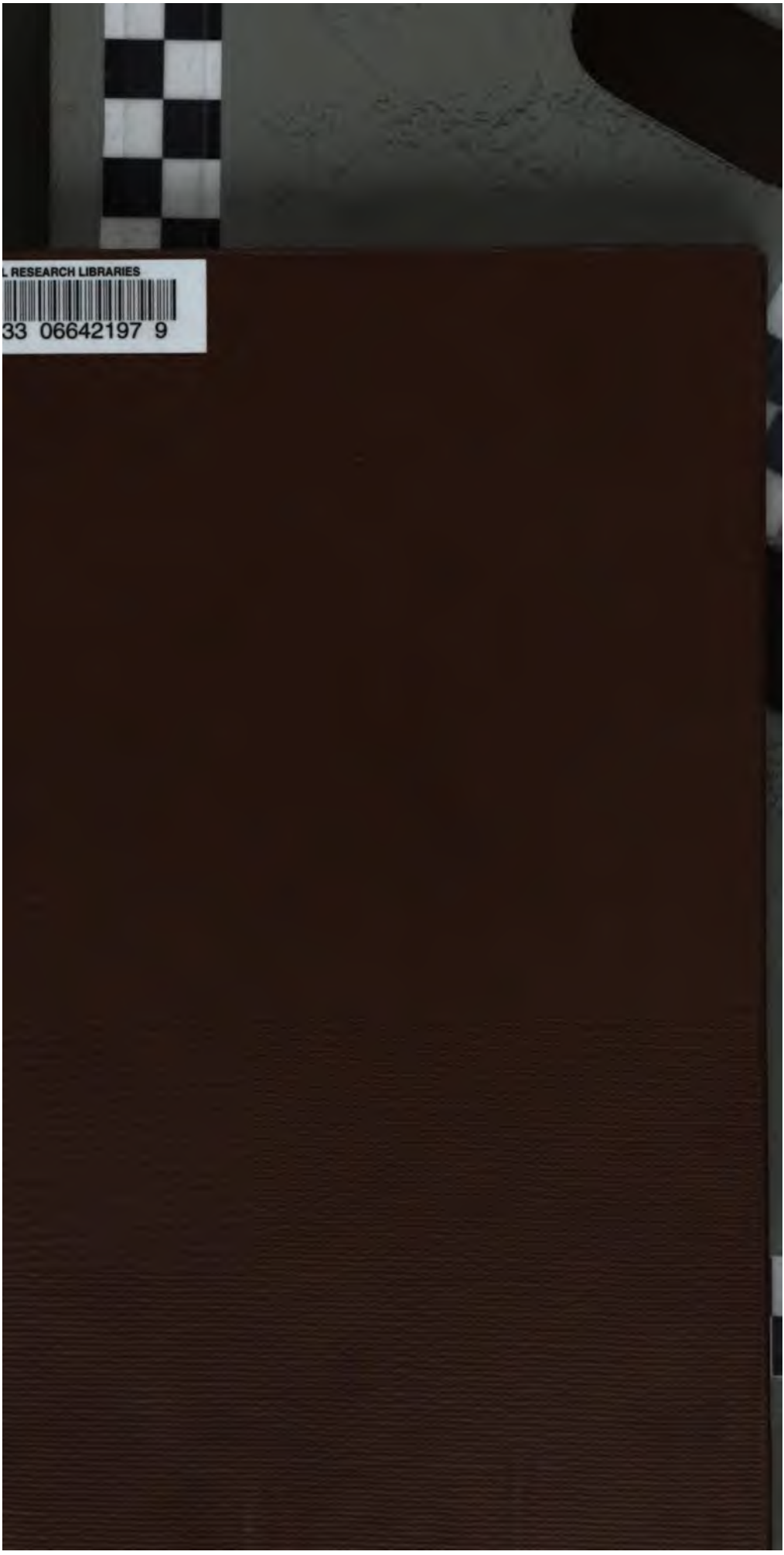
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FOURTH EDITION, MARCH, 1897.

"CAHALL"

WATER TUBE STEAM BOILERS.

CAHALL VERTICAL

AND

CAHALL-BABCOCK & WILCOX.

MANUFACTURED BY

THE AULTMAN & TAYLOR MACHINERY CO.

MANSFIELD, OHIO.

CAHALL SALES DEPARTMENT,

BANK OF COMMERCE BUILDING,

PITTSBURGH, PA.

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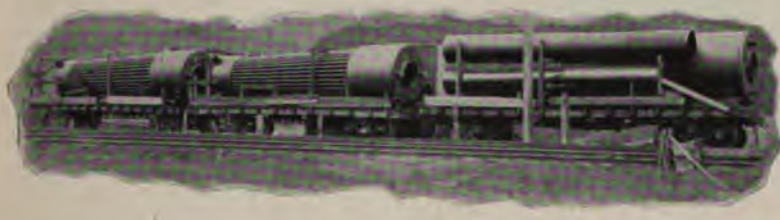
AULTMAN & TAYLOR MACHINERY CO.'S FACTORIES, MANSFIELD, OHIO.



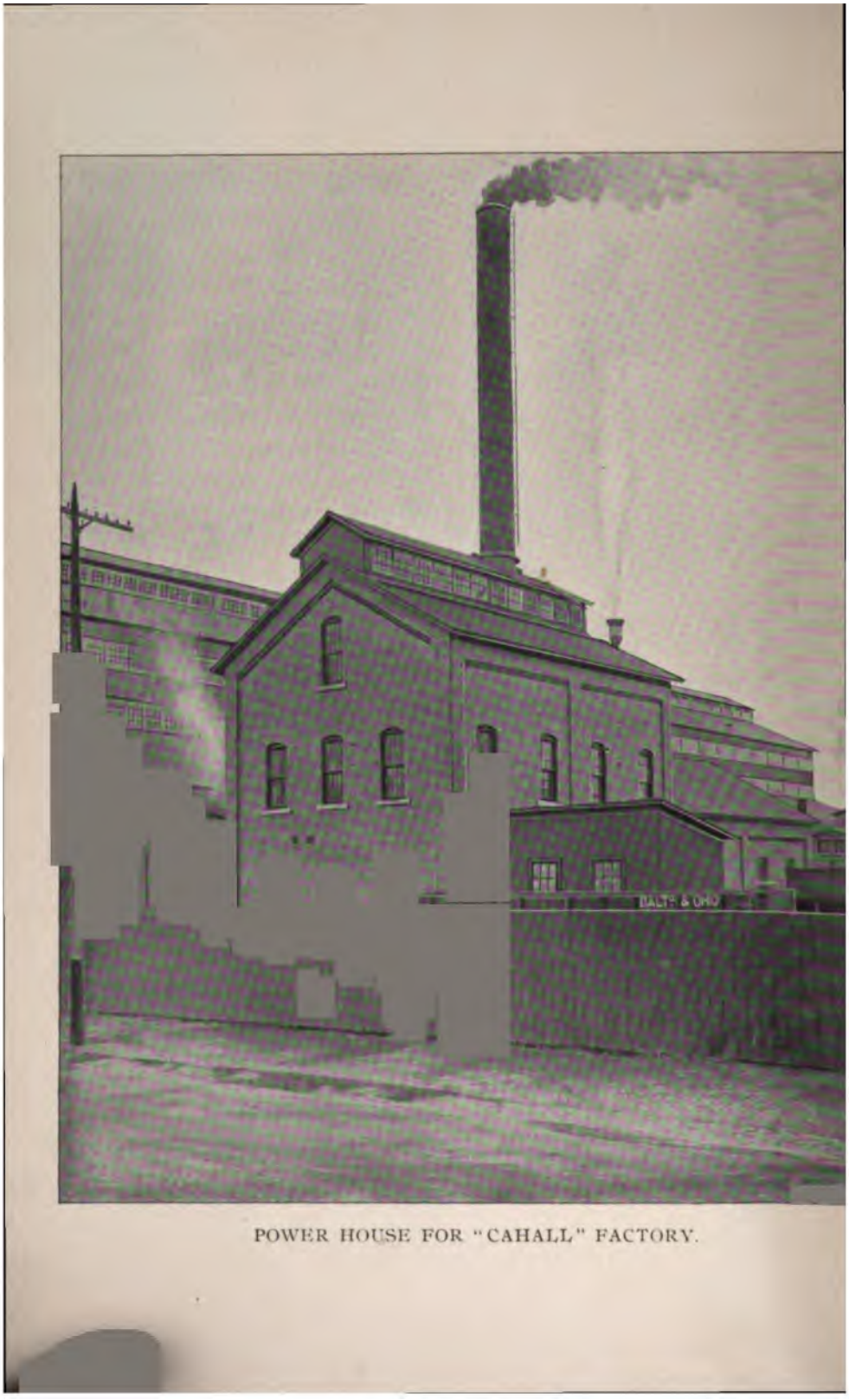
EVOLUTION OF STEAM GENERATORS.

The steady advance towards perfection can well be exemplified in the generation of steam. Some of the older class of engineers can yet remember the struggle between the old externally fired shell boiler and its then young rival, the multi-tubular. The contest between old-fogyism and advance was bitter, but progress won. Gradually the multi-tubular boiler, with its thin heating surfaces in large areas, demonstrated conclusively its superiority over its cumbersome, extravagant rival, and the shell boiler became a thing of the past. Hardly had the battle been won, when the water tube boiler entered the field to contest with the fire tube the right of existence. In the meantime the same dogged obstinacy that had fought against the introduction of the fire tube boiler transferred its allegiance from the discarded externally fired type to the fire tube type, and the war was waged all over again, and again progress won. For years past, in all high grade power plants, the water tube boiler has been selected as a matter of course. But in this, as in the evolution of the human species, there is no such thing as rest. There is no point where we can stop and say, "Thus far shalt thou go and no farther." The

W

water tube type of boiler hardly becomes the possessor of the field when another struggle occurs and the contest is on between the vertical and the horizontal water tube. Until within the last ten years the horizontal held the field because it *was* a water tube boiler; and a water tube boiler of *any* kind, horizontal or vertical, is so much superior to the fire tube boiler that it naturally survived, being unquestionably the fittest. But experience during the last decade has shown that types of water tube boilers may themselves differ from one another in their glory, even as the stars do. The horizontal water tube boiler, although far superior to its predecessor, the fire tube, is in its turn being supplanted by the vertical. When the vertical first made its appearance, it in its turn was scoffed at and ridiculed by the fraternity at large, because it was new, different, a strange thing, untried—was looked at as an innovation, and had to fight its way inch by inch into popularity over old-fogyism and prejudice; but the battle is now practically won. The increased circulation, which is positive and unintermittent; the freedom from formation of scale within the tubes in heavy masses, and the freedom from the accumulation of foreign substances outside of the tubes owing to their vertical position, the great capacity and high efficiency shown in repeated comparative tests between the new-comer and its firmly entrenched rival, have given it the preference to-day that the horizontal water tube boiler held fifteen years ago.

The vertical water tube boiler is an unqualified success, and will occupy the field until it, in its turn, must give way in the future to some new design, even as the others have done in the past. Such is the law of life and progress. It would be interesting to note, if space permitted, the step-by-step evolution of the vertical boiler from the crude experiments in which tubes of distorted shapes and different lengths were used, which, though handicapping the vertical type to a very considerable extent, still demonstrated in no



POWER HOUSE FOR "CAHALL" FACTORY.

uncertain way that, even in spite of these great mechanical faults, the vertical type as a *type* was superior to the horizontal, even with its perfection of mechanical detail, which had been laboriously evolved through a long period. But inventive genius, never sleeping, eliminated feature by feature these mechanical defects until, to-day, the vertical water tube boiler stands perfected, not only in its conception and design, but in its mechanical details, as evidenced by the Cahall Vertical Boiler, manufactured by the Aultman & Taylor Machinery Co., of Mansfield, Ohio.

Test after test has been made on this boiler for efficiency, capacity, durability and safety, and from every trial it has emerged with flying colors, until it would seem that the results obtained left nothing to be desired.

In the matter of capacity it has repeatedly developed, for long periods of time, more than twice the amount of power for which the boiler was designed.

In the point of efficiency it has delivered in dry steam more than 85 per cent. of the theoretical analyzed value of the fuel burned on its grates.

In the matter of freedom from scale accumulation it has run for a period of five years without the introduction of a scraping tool in any of its tubes, and at the end of that time shown heating surfaces as clean as the day the boiler was started, although in the same works, side by side with it, using feed water from the same source, containing the same amount of sediment, horizontal water tube boilers have, within a period of one year from their first steaming, had tubes filled solid with scale.

As to durability in the same plant above mentioned, through this whole period of five years there has never been one penny expended on the boiler proper for repairs from any cause whatever. Such a record may well cause engineers to wonder how it will be possible for a rival to arise that can equal, much less eclipse, a record like this.

A PERFECT STEAM BOILER.

The late Mr. George H. Babcock, of Plainfield, N. J., Ex-president of the American Society of Mechanical Engineers, was probably a closer student of steam boiler design and construction than any other engineer who has lived during the present century. Shortly before his death he wrote that the result of his engineering experience and scientific investigation, for a period of over 50 years in the field of steam boiler practice, had established twelve requirements of a *perfect* steam boiler.

That any steam generator should combine every one of these points all engineers of to-day, who have no particular "axe to grind," will readily admit, and we unhesitatingly agree with Mr. Babcock in his deductions.

Read carefully these twelve requirements which are, as stated, the result of over fifty years hard work, study, research and untiring experiment, and then read the description of the Cahall Vertical Water Tube Boiler which follows, and you cannot fail to be impressed with the wonderful fidelity with which this boiler fulfills every one of these absolute essentials:

REQUIREMENTS OF A PERFECT STEAM BOILER.

1st. The best materials sanctioned by use, simple in construction, perfect in workmanship, durable in use, and not liable to require early repairs.

2d. A mud-drum to receive all impurities deposited from the water in a place removed from the action of the fire.

3d. A steam and water capacity sufficient to prevent any fluctuation in pressure or water level.

4th. A large water surface for the disengagement of the steam from the water in order to prevent foaming.

5th. A constant and thorough circulation of water throughout the boiler, so as to maintain all parts at one temperature.

6th. The water space divided into sections, so arranged that should any section give out, no general explosion can occur, and the destructive effects will be confined to the simple escape of the contents; with large and free passages between the different sections to equalize the water line and pressure in all.

7th. A great excess of strength over any legitimate strain; so constructed as not to be liable to be strained by unequal expansion, and, if possible, no joints exposed to the direct action of the fire.

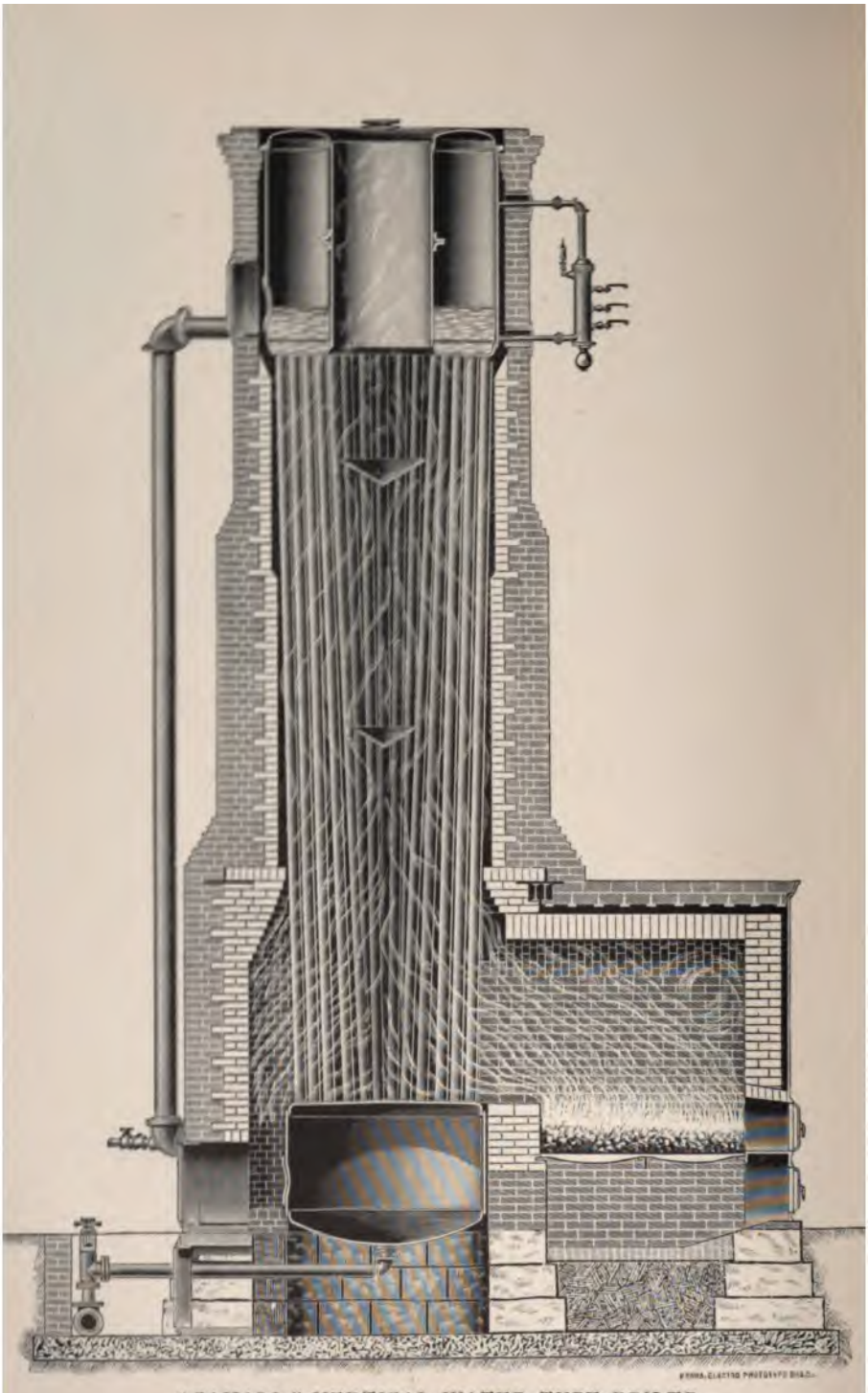
8th. A combustion chamber, so arranged that the combustion of gases commenced in the furnace may be completed before the escape to the chimney.

9th. The heating surface as nearly as possible at right angles to the currents of heated gases, and so as to break up the currents and extract the entire available heat therefrom.

10th. All parts readily accessible for cleaning and repairs. This is a point of the greatest importance as regards safety and economy.

11th. Proportioned for the work to be done, and capable of working to its full rated capacity with the highest economy.

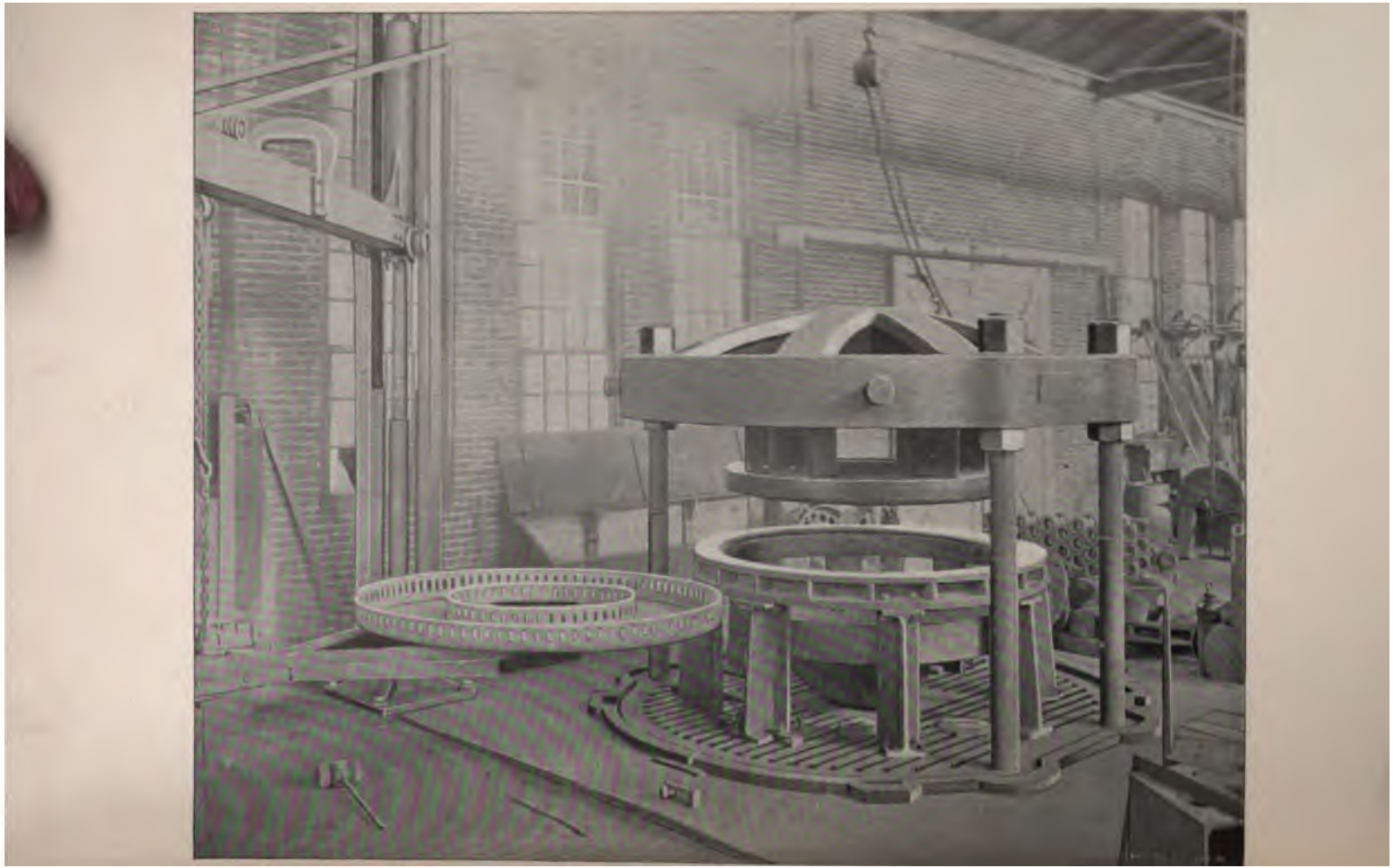
12th. The very best gauges, safety valves, and other fixtures.



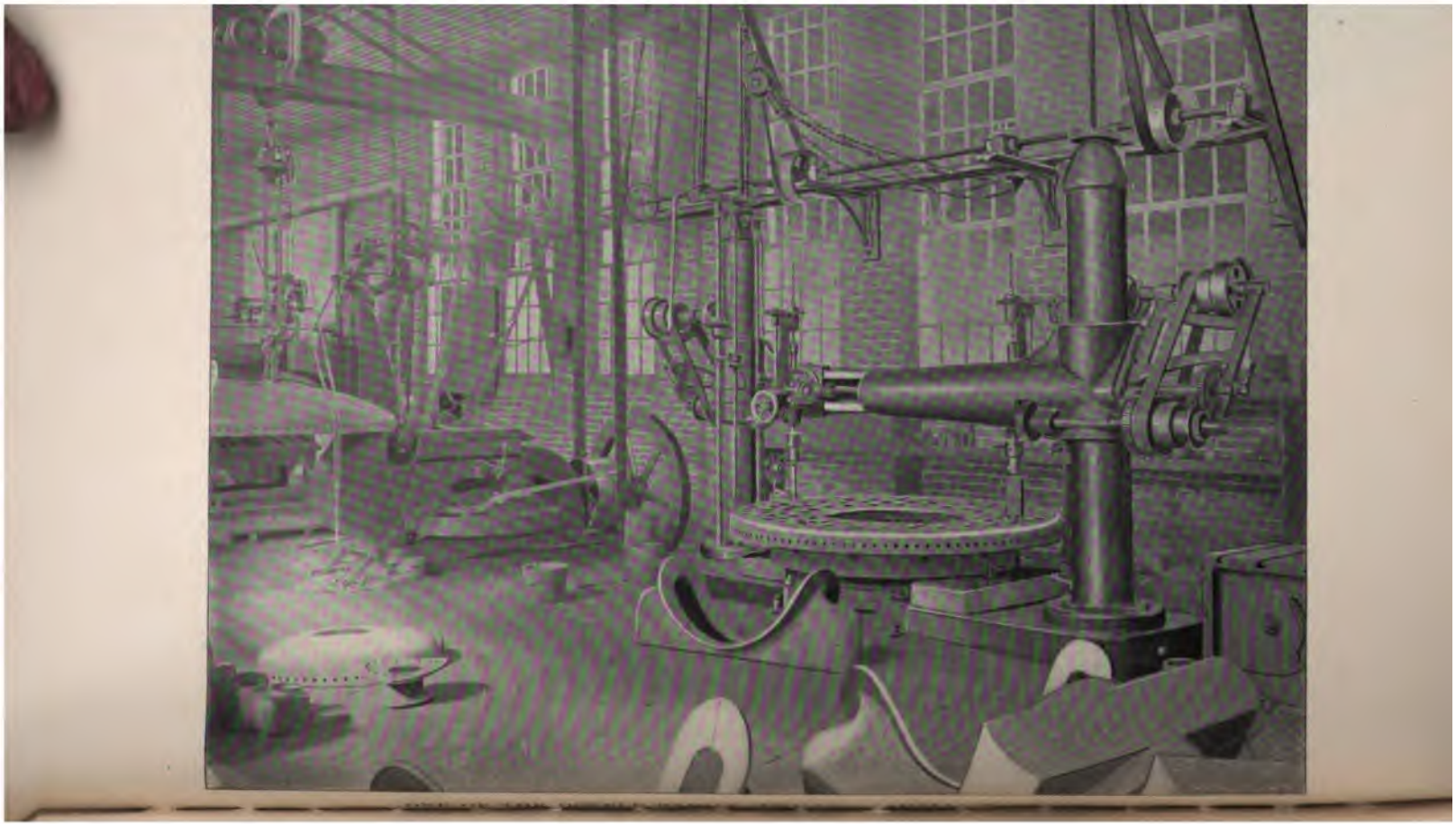
"CAHALL" VERTICAL WATER TUBE BOILER.

THE VERTICAL WATER TUBE BOILER.

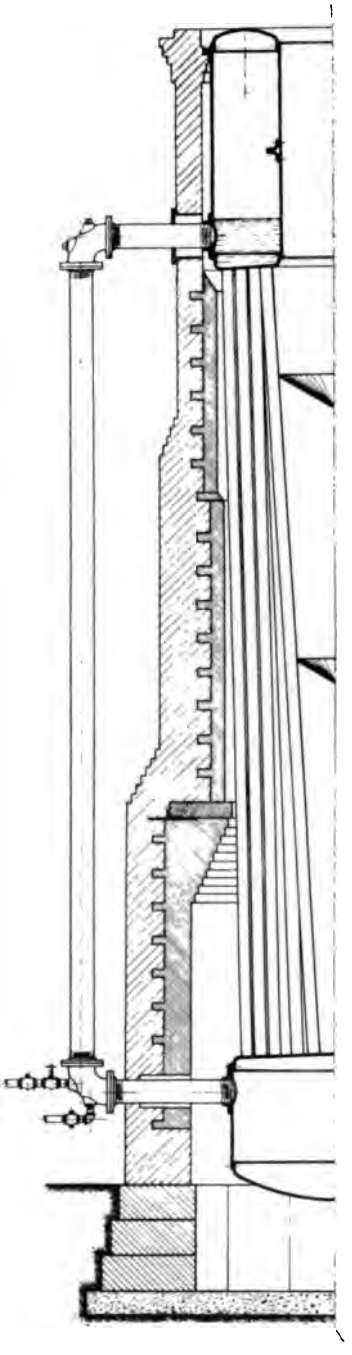
Manufactured by THE AULTMAN & TAYLOR MACHINERY CO., Mansfield, Ohio, and for which Cahall Sales Department, Bank of Commerce Building, Pittsburgh, Pa., are sole agents in the United States, consists of two drums arranged one above the other, made of best mild, open hearth flange steel, and connected with 4" lap-welded best charcoal iron tubes. These tubes are vertical, are perfectly straight throughout their entire length, and are expanded into the drums at each end, making lasting and absolutely tight joints.



The upper or steam drum has an opening through its center for the exit of waste gases. These gases, although reduced to a very low temperature in passing through the closely grouped tubes of the boiler, will impart most of their retained surplus heat to the metal sides of the passage through this upper drum, thereby tending to slightly superheat the steam in the chamber above. The water line in the upper drum is about two feet above the bottom of the drum; the drum itself being about seven feet high in the clear inside, leaving a space of five feet between the surface of the water and the point at which the steam is drawn off from the boilers, which prevents the carrying over of water with the steam, either in the form of supersaturation, or mechanical entrainment.



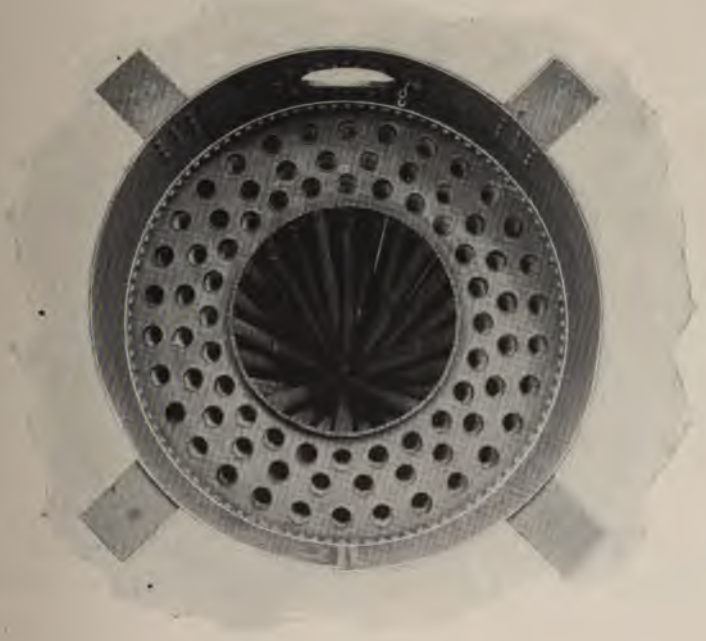
An external circulating pipe comes out from the upper or steam drum, just below the water level, and is carried downward, outside the brick work, to a point just below the tube sheet of the lower drum, where it enters that drum. There being no steam whatever in this external circulating pipe, and no possibility of making any, and there being in the tubes connecting the two drums, steam in greater or less proportions, the result is (the volume in the external pipe having a considerably greater specific gravity than the mixture of steam and water in the tubes), a very rapid, positive circulation in one direction; the water in the tubes connecting the drums ascending to the steam drum, delivers this mixture of water and steam there, whereupon the steam separates from the water and after traveling the space of five feet from the water level to the top of the drum, escapes, and the water which is left behind enters the circulating pipe and is carried down to the mud drum and again arises with its mixture of steam. As this

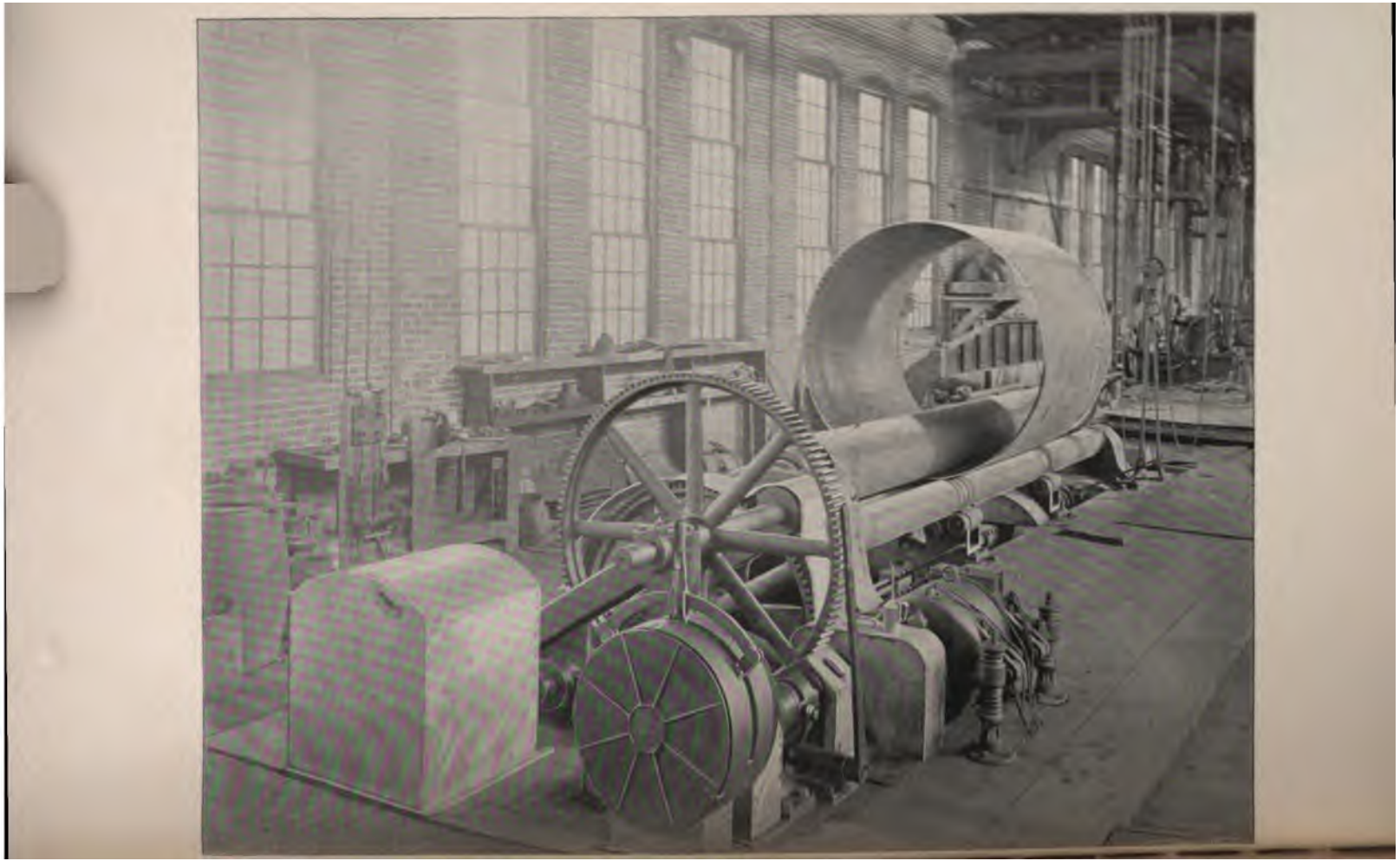


2,000 H. P. "CAHALL" VERTICAL WATER TUBE BOILERS AT CARNEGIE NATURAL GAS CO.'S STATION. BAGDAD, PA.

mixture of steam and water, coming from the upper end of the tubes into the steam drum, is in about the proportion of half steam and half water in bulk, and as steam at 100 lbs. pressure will occupy about 218 times the space occupied by the water itself, the water in the boiler (being thus delivered in the proportion of 218 parts water to one part steam by weight, at the upper ends of the tubes) will circulate through the boiler 218 times before finally becoming steam. This insures not only a rapid and steady circulation as mentioned, but also insures an absolutely uniform temperature of water in all the tubes. The boiler is thus relieved from any possibility of destructive strains from unequal expansion.

The boiler rests upon four iron brackets riveted to the



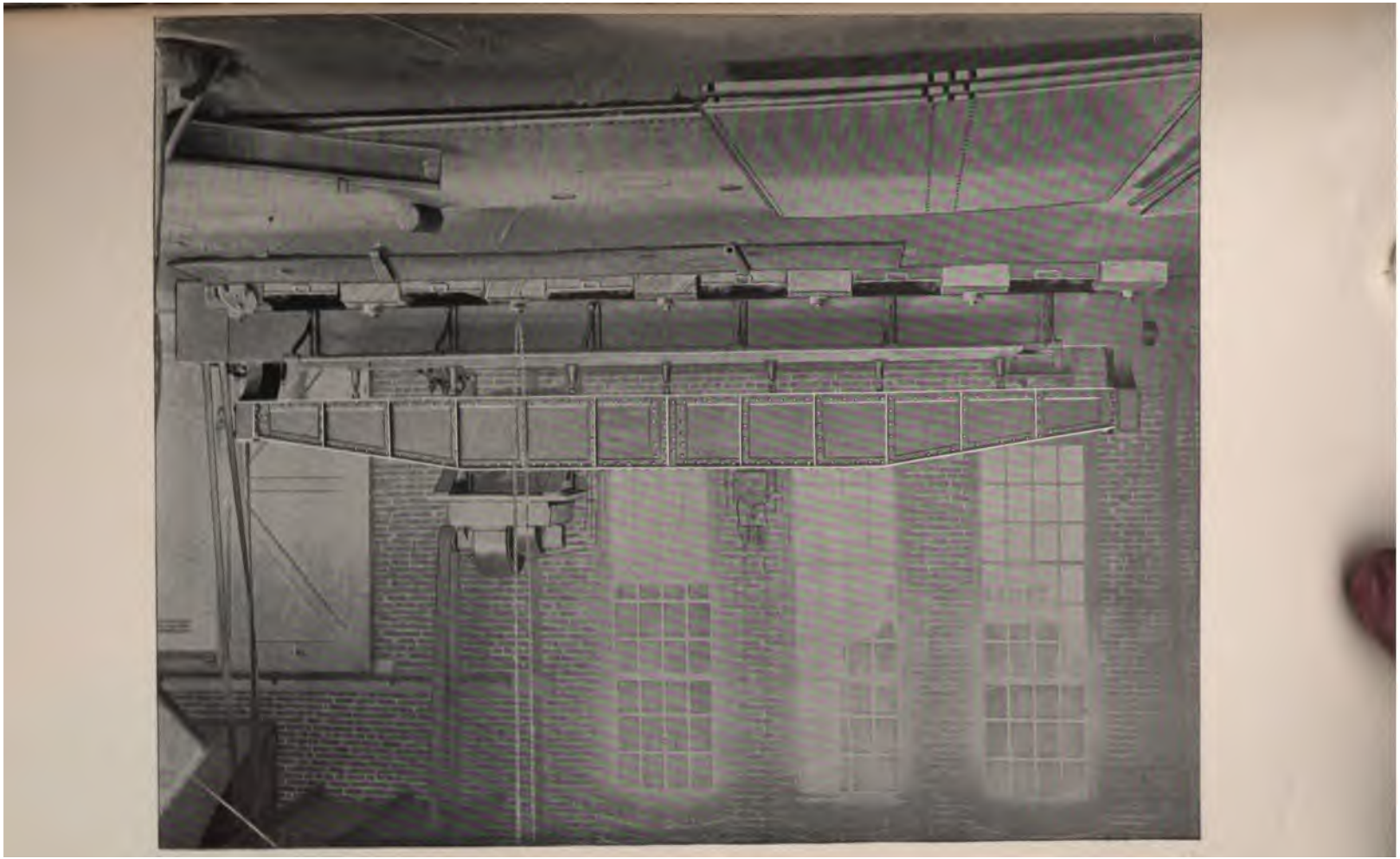


lower, or mud drum, supported upon four piers of the foundation, the entire structure standing without contact with the brick work, allowing the boiler every freedom for expansion, without in any way straining the brick setting. In all places where pipe connections are made to the boilers through the walls, they are encased in expansion boxes.

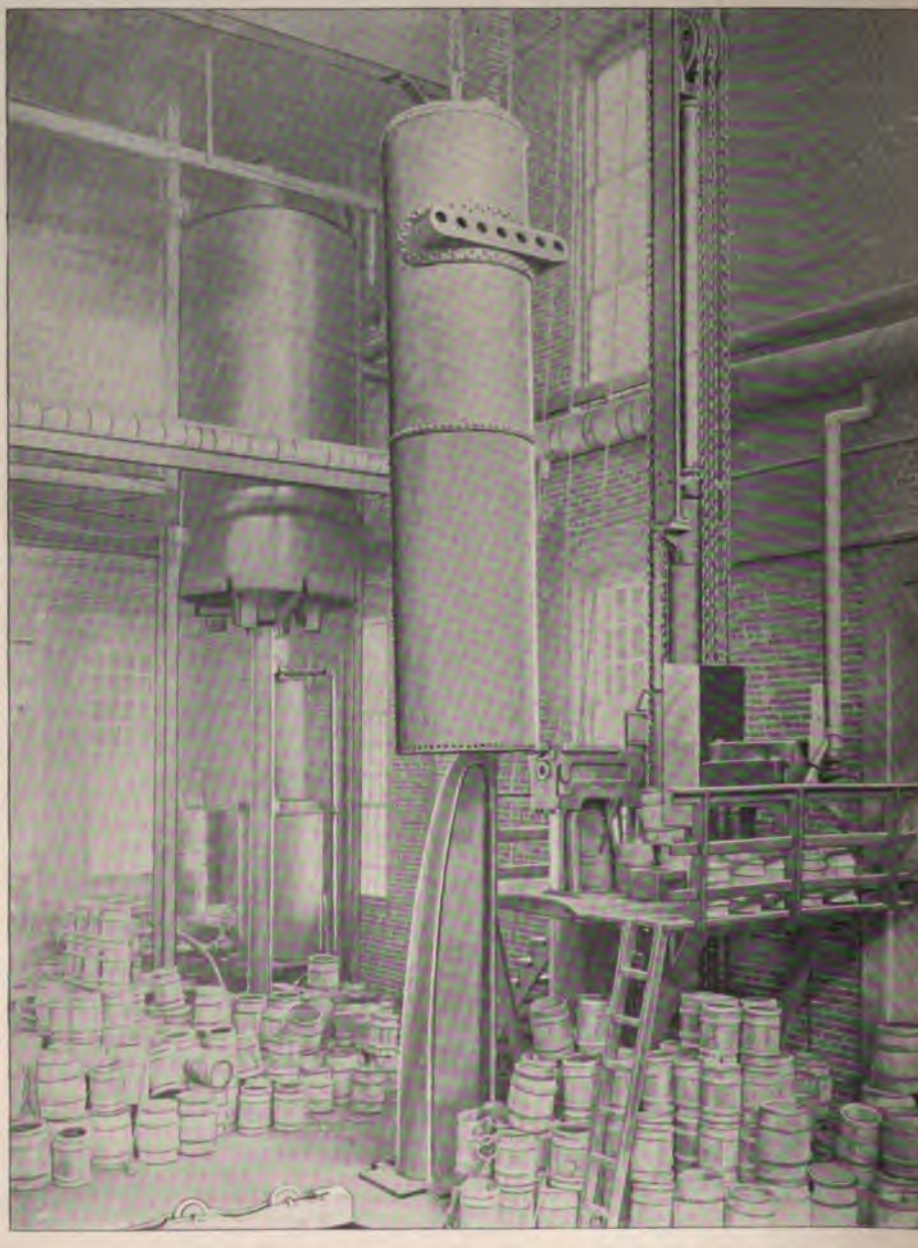
Owing to the fact that the gases escape through the central opening in the upper drum, the upper tube sheet has a circular opening in its center, leaving a central open space between the tubes, which gradually narrows to the bottom tube sheet. Advantage is taken of this space, which is in the form of an inverted cone, to introduce deflecting plates, which in connection with corresponding baffles or offsets in the brick casing cause the gases to be alternately thrown out and in throughout the whole heating surface, giving them a sweep at nearly right angles to the tubes, which extract from these gases their heat, until they come to very nearly the temperature of the water contained in the boiler.

As to the actual temperature of escaping gases from this boiler: In a test of 10 hours duration, made on a direct fired boiler, using bituminous coal, the boiler was run at an average of 30 per cent. above its rating for the entire ten hours, and the average temperature of escaping gases was 410° Fah. On another test made on a 150 horse power direct fired boiler, using bituminous coal as fuel, the boiler was forced to 120 per cent. above its rating, delivering 330 horse power, and at no time, even at this phenomenally high rate of evaporation, did the temperature of escaping gases reach 600° Fah.

This construction presents a form of boiler which, while from its free, direct circulation gives large capacity per square foot of heating surface, at the same time, owing to the direction of the gases over the tubes and the consequent rapid absorption of the heat therefrom, gives an economical performance exceeding that of any other boiler in the market.



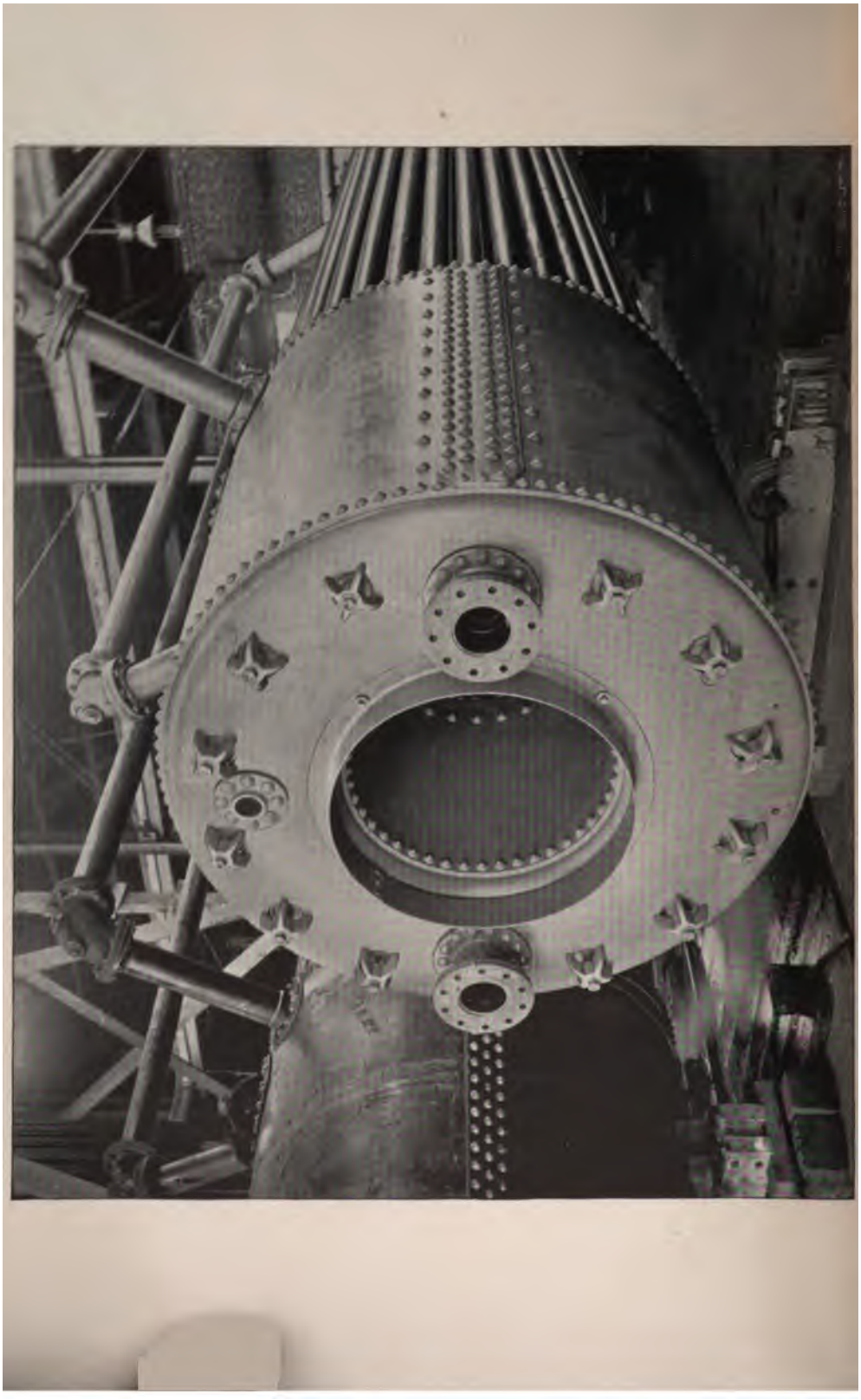
The upper, or steam drum, and the lower, or mud drum of the boilers are equipped with the Cahall patent swinging man-head. By simply taking off the nuts from the man-heads and swinging them open and placing a light in the lower drum, one can from inside the upper drum (which is sufficiently large to admit of a man standing upright and walking around in it) in five minutes examine the condition of every tube in the boiler, and in case scale or sediment is discovered in any of them, can in a few minutes run a scraper through such tubes and render them perfectly clean. The scraper used for cleaning these tubes is made in sections a trifle less than six feet long. Four of these sections are used, and the man who is cleaning the boiler takes them into the upper drum and pushes the first section down as



MAIN HYDRAULIC RIVETER, "CAHALL" FACTORY.

far as it will go, then connects the second section to that, and continues doing this until the scraper has gone entirely through the tube, forcing any scale matter that may have deposited on the sides of the tube straight through to the bottom drum. This form of scraper is very easily handled and takes little time to connect or disconnect, and will thoroughly remove every particle of scale that may form. It will be found in actual practice that the use of the scraper in these boilers will be very seldom necessary, as, for instance, many boilers in use for over five years have never, up to and including the present time, had a cleaner in a single tube.

Right here it might be well to mention that very seldom is a tube in a water tube boiler burnt out on account of a general or uniform deposit of scale on its surface. Most tubes failing are burned because a light scale, having accumulated in the tubes, patches of it become loose and fall to the bottom of the tube, and remain there, because the tube lies in an approximately horizontal position. There are many instances where boiler tubes scale uniformly to the thickness of an inch, without any loss from burning. On the other hand, a single patch of scale less than an inch in diameter and one-eighth inch thick, on an otherwise clean tube, frequently causes the tube to burn out at the point where the scale is deposited. It will be seen that, from the arrangement of the tubes in the Cahall boiler, any scale that might loosen will at once fall to the mud drum at the bottom, and, if small enough, will be blown out through the blow-off pipe; if too large for this, it can be removed through the man hole on regular cleaning day. As the entire lower drum is removed from direct contact with the fire, the presence of scale in this drum can act in no way to the detriment of the boiler, as, the fire not being in contact with the drum, it could not burn, even were the drum allowed to become half filled with scale.



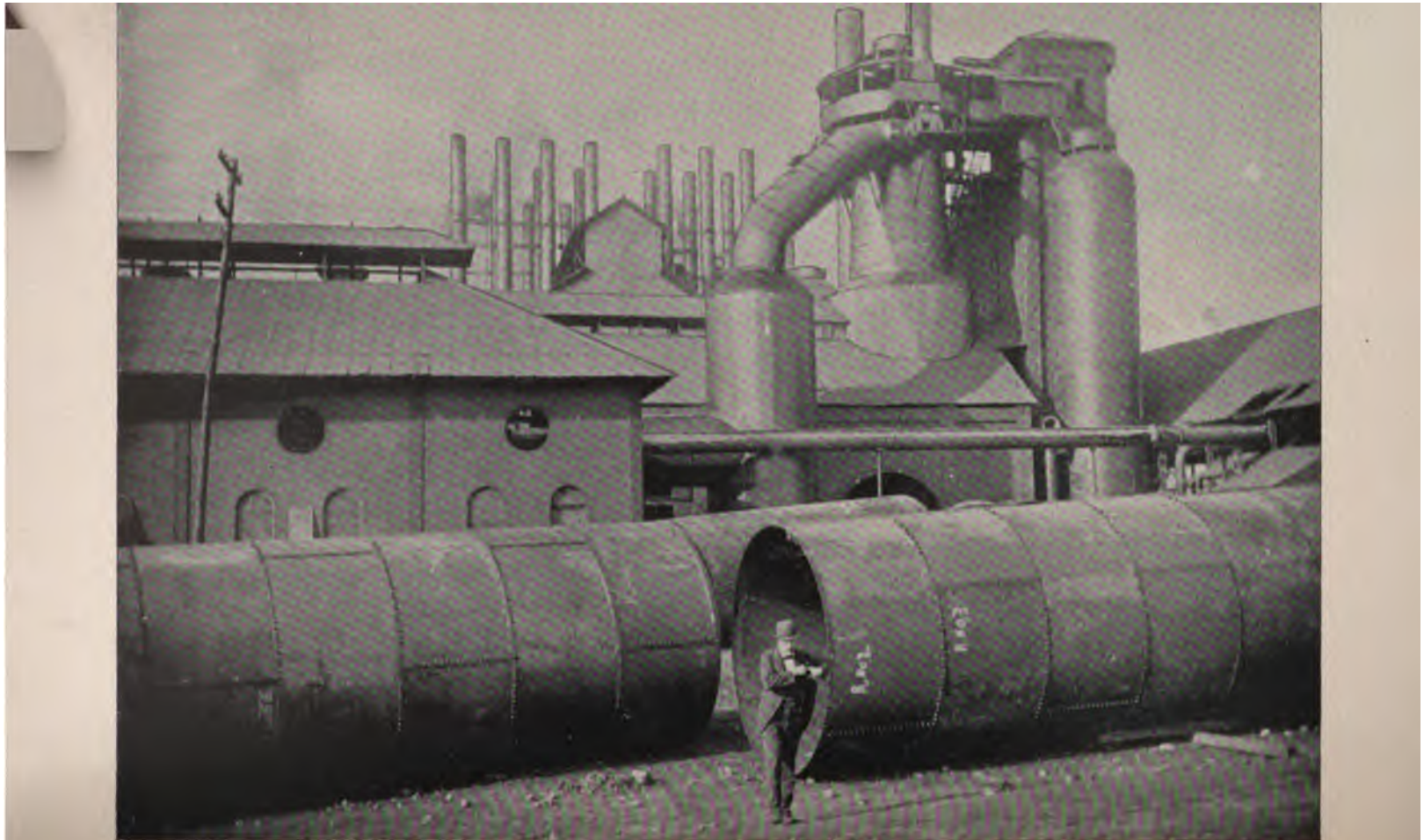
Ample provisions are made for removing defective tubes from the boiler, in the following manner: An examination of the steam drum cut will show the reader that in the upper or top head of the steam drum there are placed hand holes, which are closed by means of plate, yoke and bolt, in the usual manner; that there are, in addition, other holes used, one for the steam pipe connection, the other for the pop valve connections. By means of these openings tubes needing removal, after having been cut loose from the tube sheets, can be pushed up through the tube hole from which it has just been cut and through the most convenient of these openings in the top head, and removed from the boiler. The new tube to replace the defective tube is passed into the boiler through the same openings.

In the waste-heat type of boiler the same provisions are made, and, in addition, as the whole top of the steam drum is completely covered by the cone-shaped hood forming the base of the smoke stack, there are placed in the sides of the cone, at proper distances, openings, closed by doors, through which the tubes, after having been pushed up through the drum, are taken out and the new ones passed back again, without interfering at all with the stack.

All materials furnished in and with this boiler are of the very best; the workmanship is of the highest grade known to the boiler making art; the safety valves are all of the latest improved pop type, with nickel seats; the fittings and valves are all specially designed, extra heavy, and the best that money can procure.

We are determined to make this the world's standard water tube boiler, and no care or expense will be spared to make it such.

The external combustion chamber, roofed with a heavy fire-brick arch, becomes incandescent shortly after the boiler is fired, and radiates directly on top of the green coal its intense heat, and enables the Cahall boiler to be operated



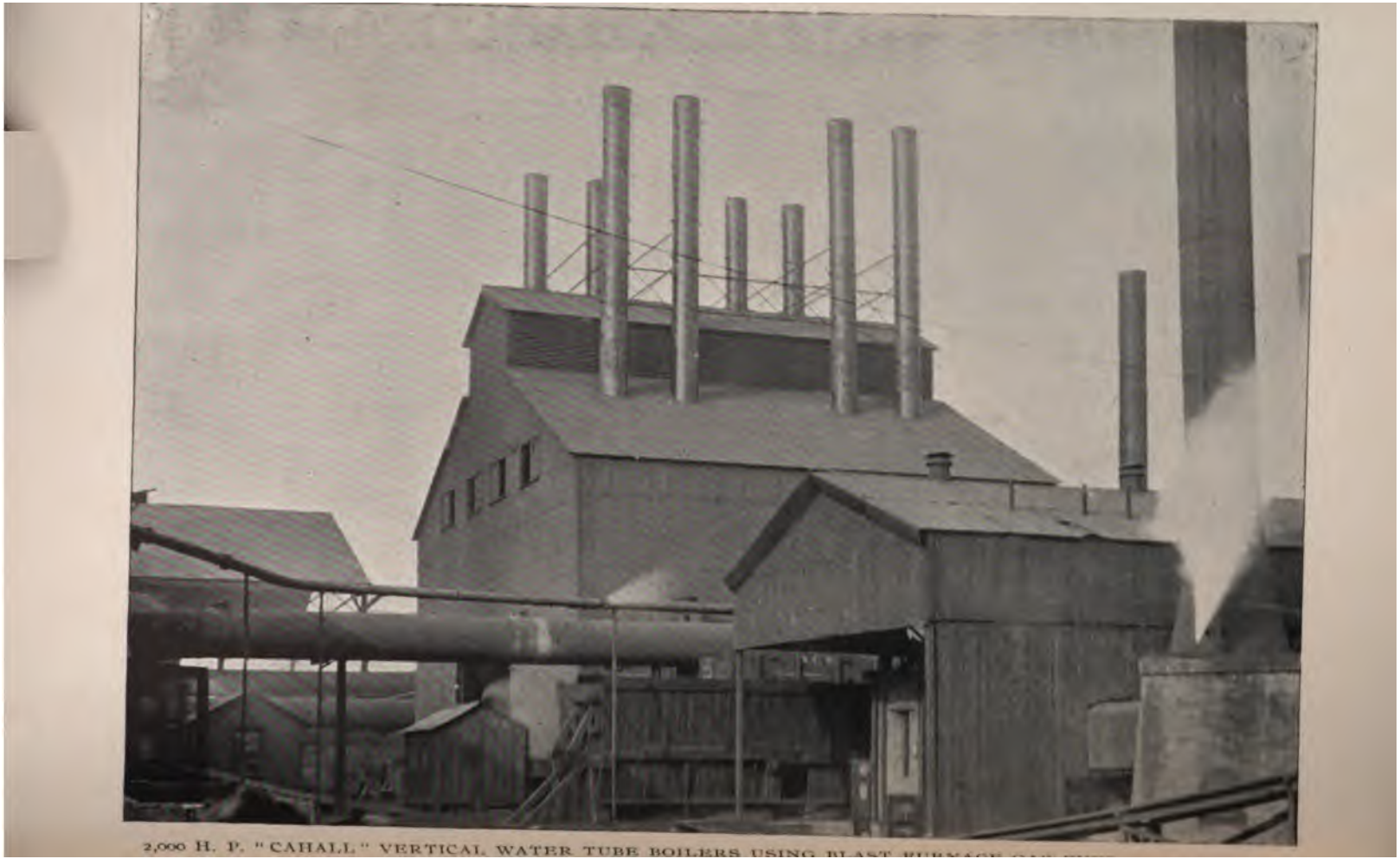
CARNEGIE STEEL CO.'S "EDGAR THOMSON" WORKS, BRADDOCK, PA., CONTAINING 6,050 H. P.

with less smoke than any other boiler can with the ordinary smoke preventing devices attached. Furthermore, owing to the direct upward passage of all gases and full, free openings, it can with a comparatively short stack obtain in the furnace a draft pressure that is not possible with most other boilers. For instance, in tests made with a stack only 50 feet high a draft pressure in the furnace of over one-half inch was attained, which is a result that we doubt could be obtained from any other water tube boiler with a stack 100 feet high. This heavy draft causes a very rapid combustion of fuel per square foot of grate, with the consequent high initial temperature of gases, which all engineers admit is the primal requisite to efficiency in boiler practice.

To sum up, we furnish a boiler equaled by none built, in quality of material, in excellence of workmanship, in surplus capacity per nominal unit, in evaporative efficiency, and in ease of examination and cleaning.

"CAHALL" BOILERS FOR BLAST FURNACE GASES.

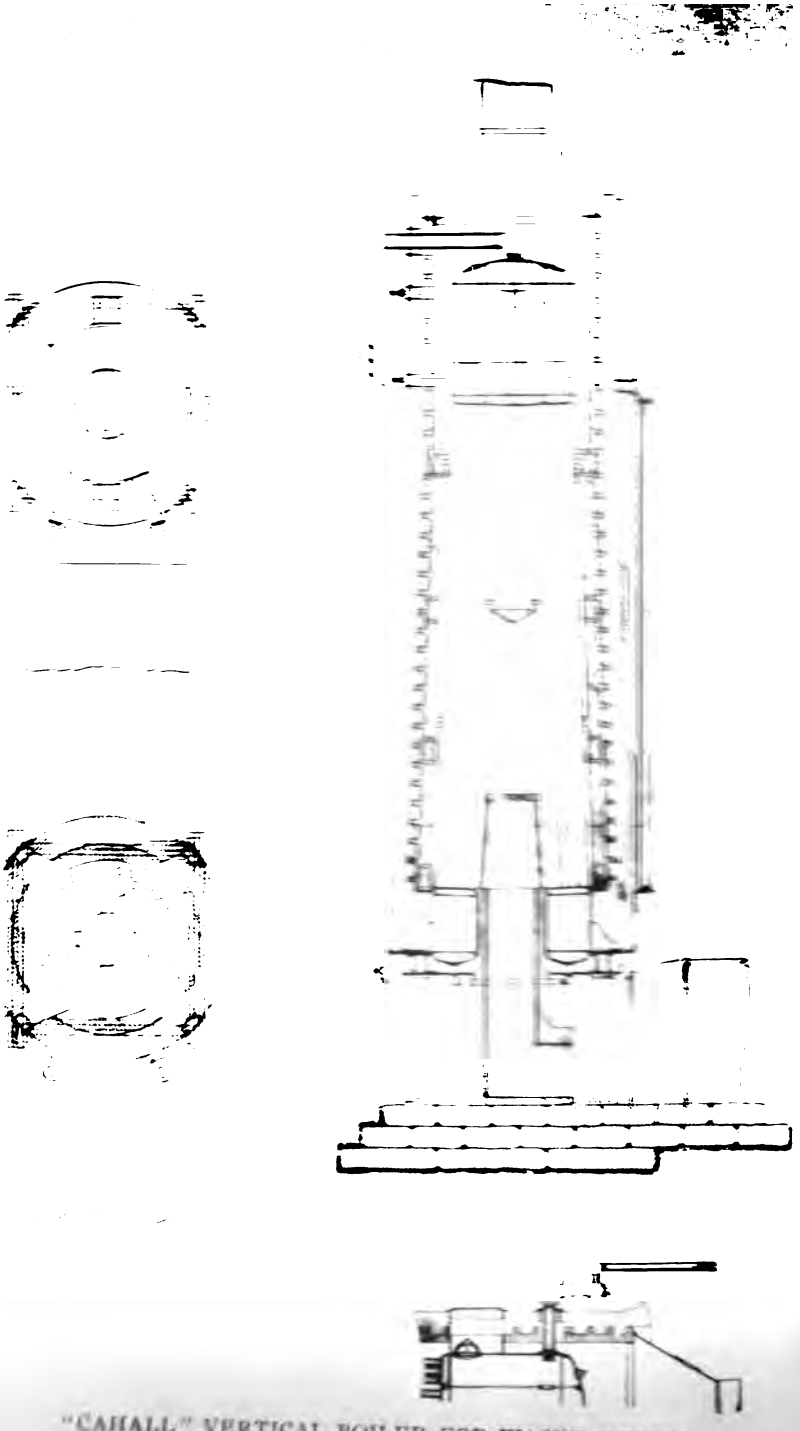
From the foregoing description it is noticeable that this boiler is most admirably adapted for the use of blast furnace gases, the external combustion chamber imparting as it does its intense heat to the entering gases, puts them in a condition that enables them to take fire instantly and burn freely and quickly. None of the heavy metal sheets of the boiler being in contact with these flames, the intense heat thus generated can have no harmful effect, as it is thrown directly against the very thin metal surfaces of the tubes, the heat



2,000 H. P. "CAHALL" VERTICAL WATER TUBE BOILERS USING BLAST FURNACE GAS

from which is readily absorbed by the water contained therein, in the thin columns into which it is subdivided. In tests of boilers using blast furnace gases for fuel, an initial temperature of combustion of over 3,000 degrees has been obtained, and yet the gases are brought so thoroughly in contact with these thin heating surfaces that by the time they reach the opening in the upper drum their temperature is reduced to between 400 and 500 degrees, thus giving an efficiency higher than has ever been obtained by boilers of any type using blast furnace gases as fuel. These highly heated gases, impinging directly on the thin heating surfaces, of course make steam with extreme rapidity and the heating surface in these boilers being figured more conservatively than in that of any other water tube boiler, allows a great excess over the nominal or rated capacity of the boilers to be taken from them without materially affecting the economy.

The use of fine ores is becoming more general every year, their low first cost more than counterbalancing the disadvantages which are claimed to result from their use by some furnacemen. One of the principal among these is the fact that a large quantity of fine ore is carried over with the gases to the boilers. Where boilers with horizontal, or approximately horizontal heating surfaces are used, this really becomes a serious drawback, as the ore, together with the other dust always present in furnace gases, piles up so rapidly that it soon stops up all the passages for the heated gases. The "Cahall" boiler, from its construction, is freed entirely from this trouble, as the surfaces being practically vertical, there is no chance for the accumulation of dirt of any kind on the heating surfaces. It all falls to the bottom part of the boiler, where ample provisions are made for readily and easily removing it whenever occasion requires.

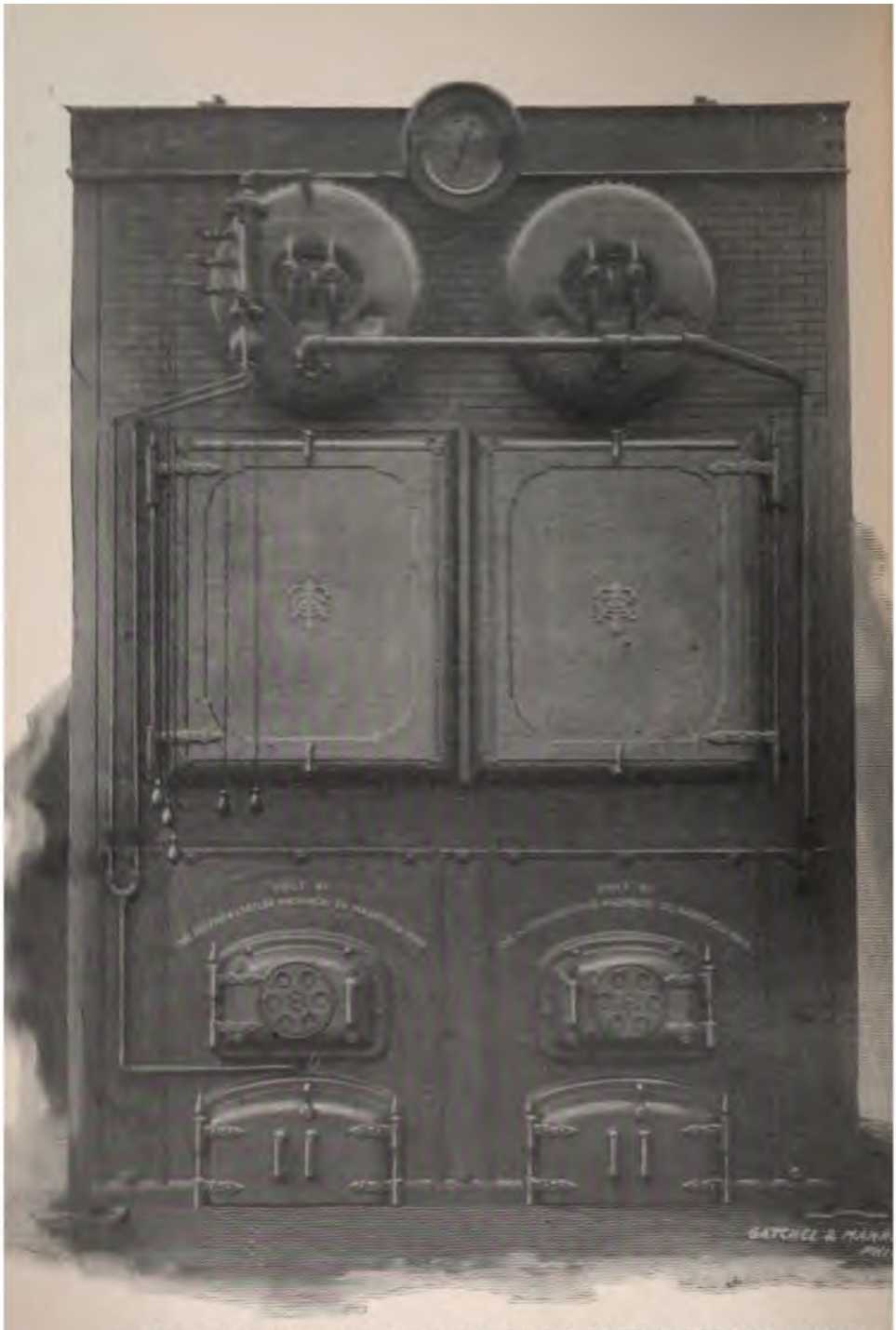


"CAHALL" VERTICAL BOILER FOR WASTE HEATS.

"CAHALL" BOILERS FOR UTILIZING WASTE HEATS.

For many years it has been a problem, not only in rolling mills, but in many other industries, how best to utilize the waste heats from heating or puddling furnaces. In many instances manufacturers have gone to the enormous expense of building elaborate regenerative furnaces of various types, which not only necessitate a very high first cost, but great expense for repairs, which also require considerable time to effect. In any plant where furnaces of any kind for heating or puddling are used, and where there is any steam power required, the ideal method for utilizing the heat from these gases is to make steam with it.

We have a special design of boiler (cuts of which are shown) intended solely for the purpose of utilizing these waste heats. It is much cheaper to build a good reverberatory furnace and attach a boiler thereto, than it is to build a first-class regenerative furnace, and in most plants, especially in the iron and steel industry, sufficient steam power can be generated from waste heats to run the entire works, thereby not only saving the cost of the fuel now being burned under existing boilers, but saving the room occupied by those boilers and the wages of the firemen necessary to handle the coal and ashes. In general practice, the waste heat boiler applied over a heating or puddling furnace will deliver a horse power for each five pounds of coal fired in the furnace per hour, and with coal at $1.00 a ton, a horse power of steam costs, with boilers direct fired, about $25.00 per annum. A heating furnace, therefore, consuming the equivalent of 600 pounds of coal an hour, will deliver steam from its waste heats aggregating 120 horse power, or a money value of about $3,000 per year, with coal at $1.00 per ton, delivered.

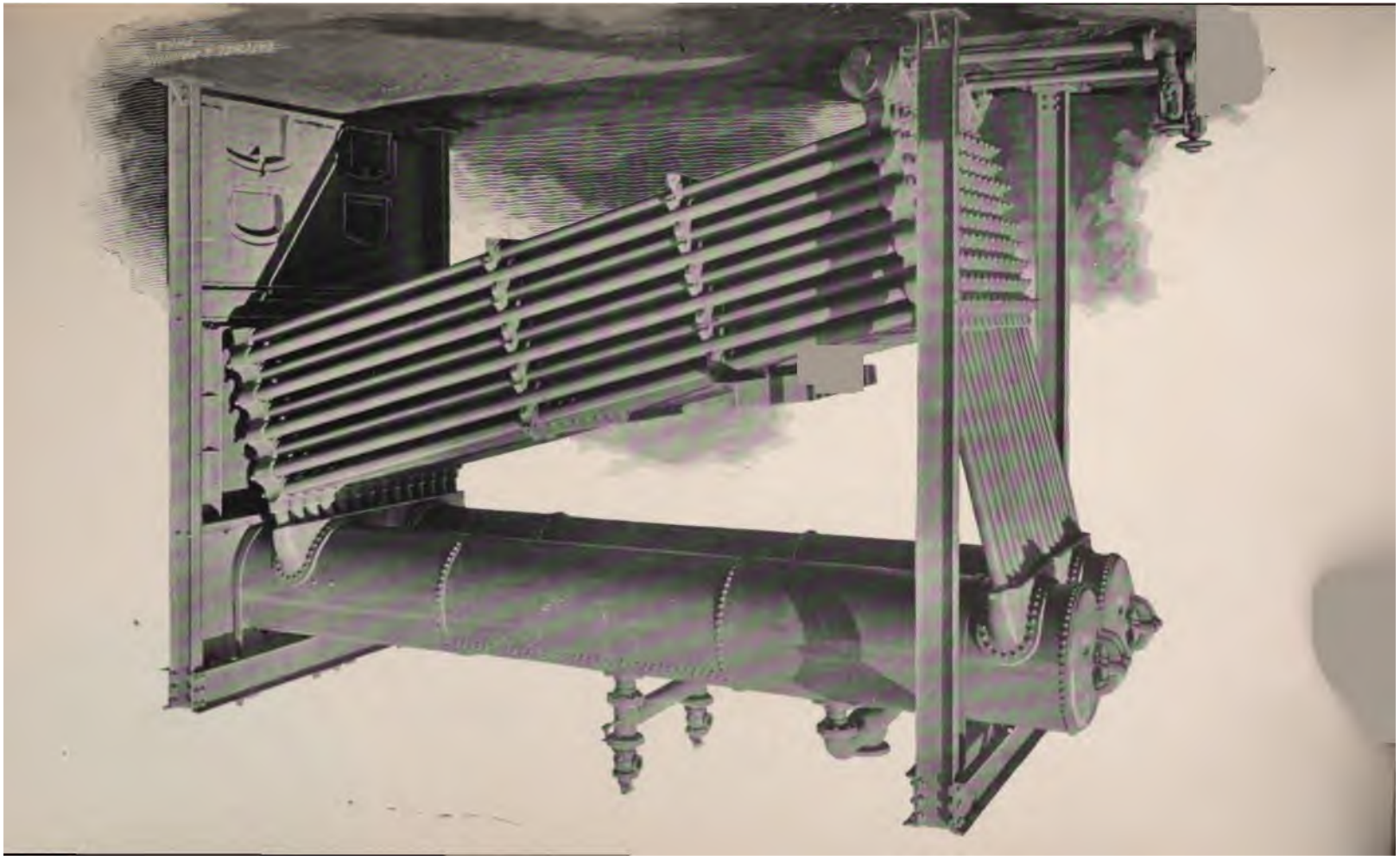


FRONT VIEW OF 250 H. P. "CAHALL" BABCOCK & WILCOX BOILER.

This amount of saving will, each year, more than pay the entire cost of the boiler plant complete, ready for steam; in fact, in the Pittsburgh district, where coal can be procured at the very low price of sixty cents per ton, delivered, we have several plants of these waste heat boilers running, on which the saving on coal alone pays an annual dividend of from 115 per cent. to 140 per cent. on the first cost of the boiler plant complete. This is a very important subject, and one that requires careful consideration on the part of manufacturers having places wherein to make installations of this kind, and we would like very much to open correspondence and furnish drawings and estimates for installing these waste heat boilers in places where it is possible.

CAHALL-BABCOCK & WILCOX BOILERS.

The six illustrations given show the Babcock & Wilcox type of boilers manufactured by the Aultman & Taylor Machinery Co., at Mansfield, Ohio, who are also the manufacturers of the "Cahall" Vertical Water Tube Boiler. Some time ago, finding that there were many locations where it was impossible, on account of lack of space, to install a vertical boiler, the Aultman & Taylor Machinery Company decided to build a horizontal water tube boiler in addition to their vertical. After thorough investigation they decided that the Babcock & Wilcox type had shown the best results of any of the horizontal water tube boilers in the market, and they therefore adopted this type for their horizontal boiler, which they call the Cahall-Babcock & Wilcox, to distinguish it from the Cahall Vertical.

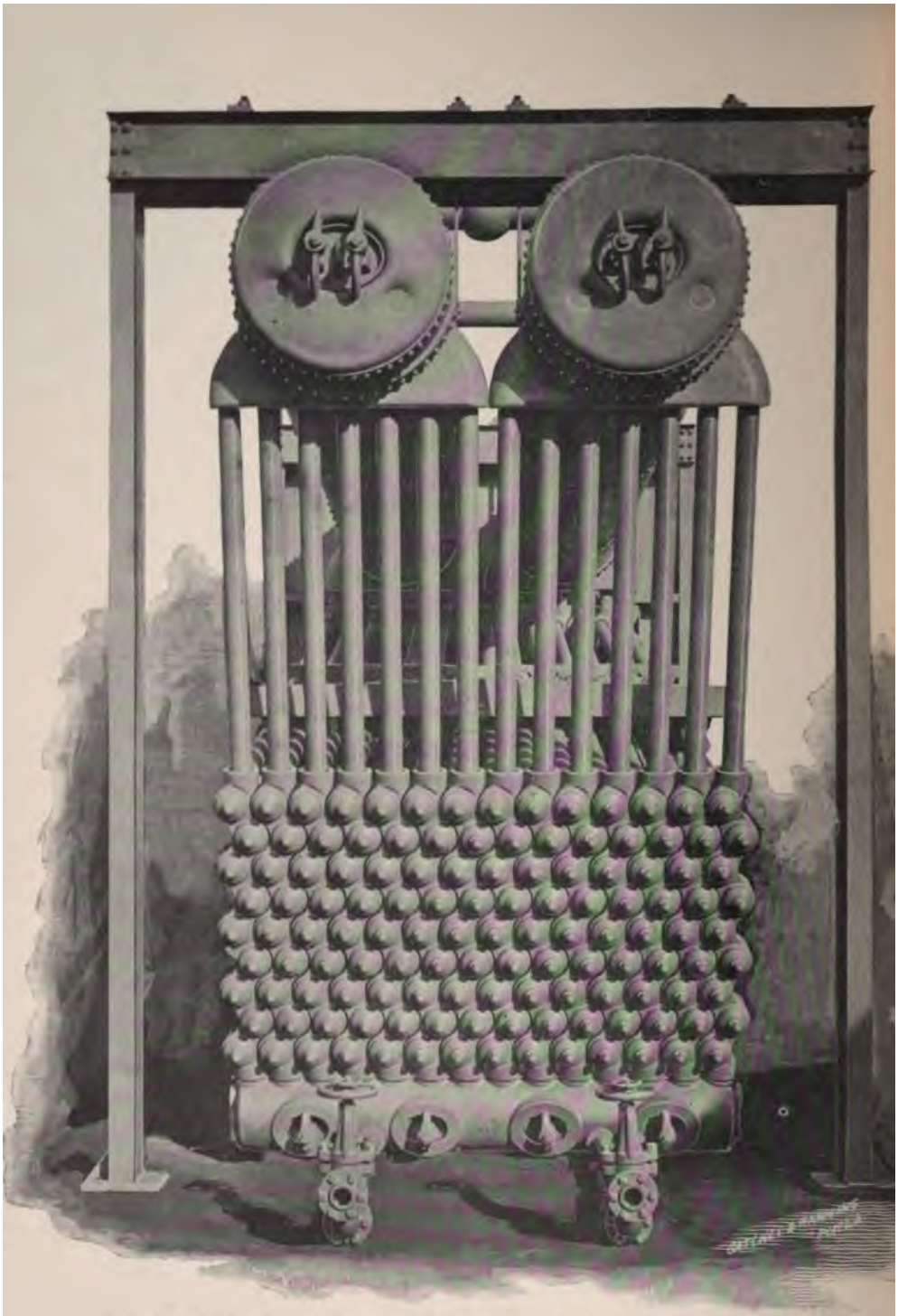


These boilers are built in sizes of from 125 h. p. up to 500 h. p. in single units. They also build what is known as the "double-decker" type of this same boiler. The boilers are built for working pressures of from 160 lbs. to the square inch up to 500 lbs. to the square inch.

The factories of the Aultman & Taylor Machinery Co., at Mansfield, Ohio, are ample in size, are new, and equipped with the very latest tools and machinery. With the exception of the hydraulic and pneumatic plant, all the tools in the factory are direct electrically driven. The factory has an annual capacity of 200,000 h. p. of Cahall Vertical Boilers and 100,000 h. p. of Cahall-Babcock & Wilcox Boilers with the present facilities.

Going into specific detail as to the manufacture of these boilers, we will begin with the steam drums. These are made of best open hearth flange steel, the heads for the drums being of the same material, hydraulically flanged. All the sheets are beveled on the edges, bent into shape, and the rivet holes drilled after bending. This insures absolutely round holes without crystallization and allows calking of all seams, both inside and out. In boilers, the working pressure of which is not to exceed 160 lbs. to the square inch, the longitudinal seams in the drums are double riveted. In the higher pressure boilers, that is from 160 up to 250 lbs., all horizontal seams are butt and double strapped joints with six rows of rivets. This makes the very finest possible joints, and when made with the care that is always exercised in our factories, is really a piece of fine art in boiler manufacture.

Each drum is provided at both ends with the Cahall patent swinging man-head. This device, although very simple, is something of great importance. Engineers who have been annoyed with the laborious and tedious practice of taking man-heads out of boilers and lifting their heavy weight to a place of security, and then going through the annoyance of

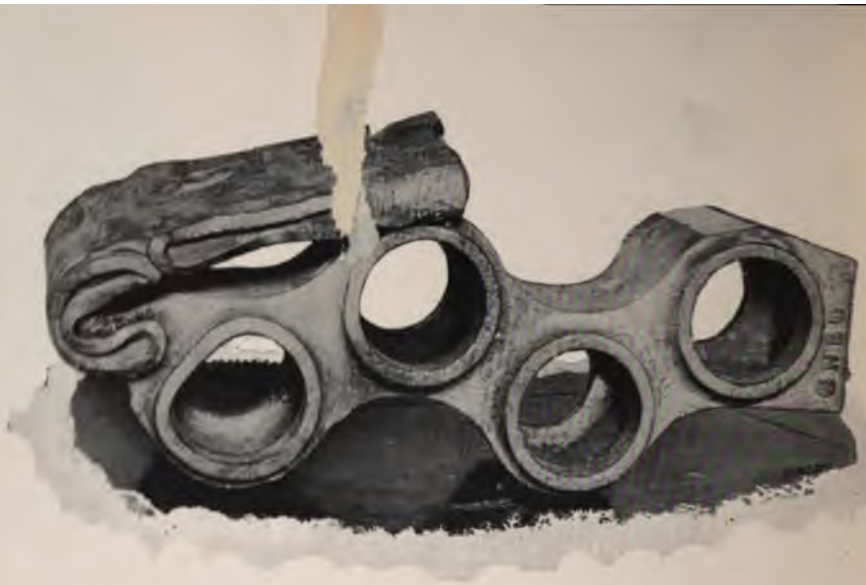


REAR VIEW OF 250 H. P. "CAHALL" BABCOCK & WILCOX BOILER,
SUSPENDED READY FOR BRICK WORK.

putting them back in their places again after the work in the boiler is finished, will appreciate fully the device which is furnished with these boilers. By simply loosening the nuts on this man-head, a slight push swings the head in as though it were a door, and it fits back in place against the drum, without occupying any appreciable amount of room, and when the time arrives to again close it, it is pulled back to its place. Being hinged, as it is, the seats come together in exactly the same place every time, and the joint being made tight once is tight for all time, less than one minute being required to open the man-head and close it perfectly tight.

The flanges on the steam drums for the steam and safety valve openings are all drop forged, from flanged steel plates.

It will be noticed from the rear view of the boiler in the accompanying illustrations, that each section of tubes is connected by nipples to cross-boxes, or saddles, on the steam drums. In all other boilers of this type made at the present time, these cross-boxes are manufactured either of flanged steel plates or cast iron. Both of these are improper. If made of cast iron, it is impossible to have the curvature of the box conform exactly to the curvature of the drum, and when they are riveted in place either one of three things must occur: (1) The sheets in the drums are distorted, (2) the cast iron is cracked from the pressure, or (3) a leaky joint is made. The leaky joint is the most frequent result. When the manufacturers find this they generally attempt to calk up the space with various metals, lead or Babbitt metal having been used in many cases, with the result that might be expected. After the boilers have been tested and accepted, the metal melts out and serious and irreparable leaks develop The flanged cross-boxes are wrong for the reason that being made as they are, of a flat sheet, which through successive heatings and applications of hydraulic pressure are bent around sharp corners, resulting in a great



SAMPLE OF HEADER MADE BY "FLOWED" STEEL PROCESS.

BORINGS AND TURNINGS OF "FLOWED" STEEL.

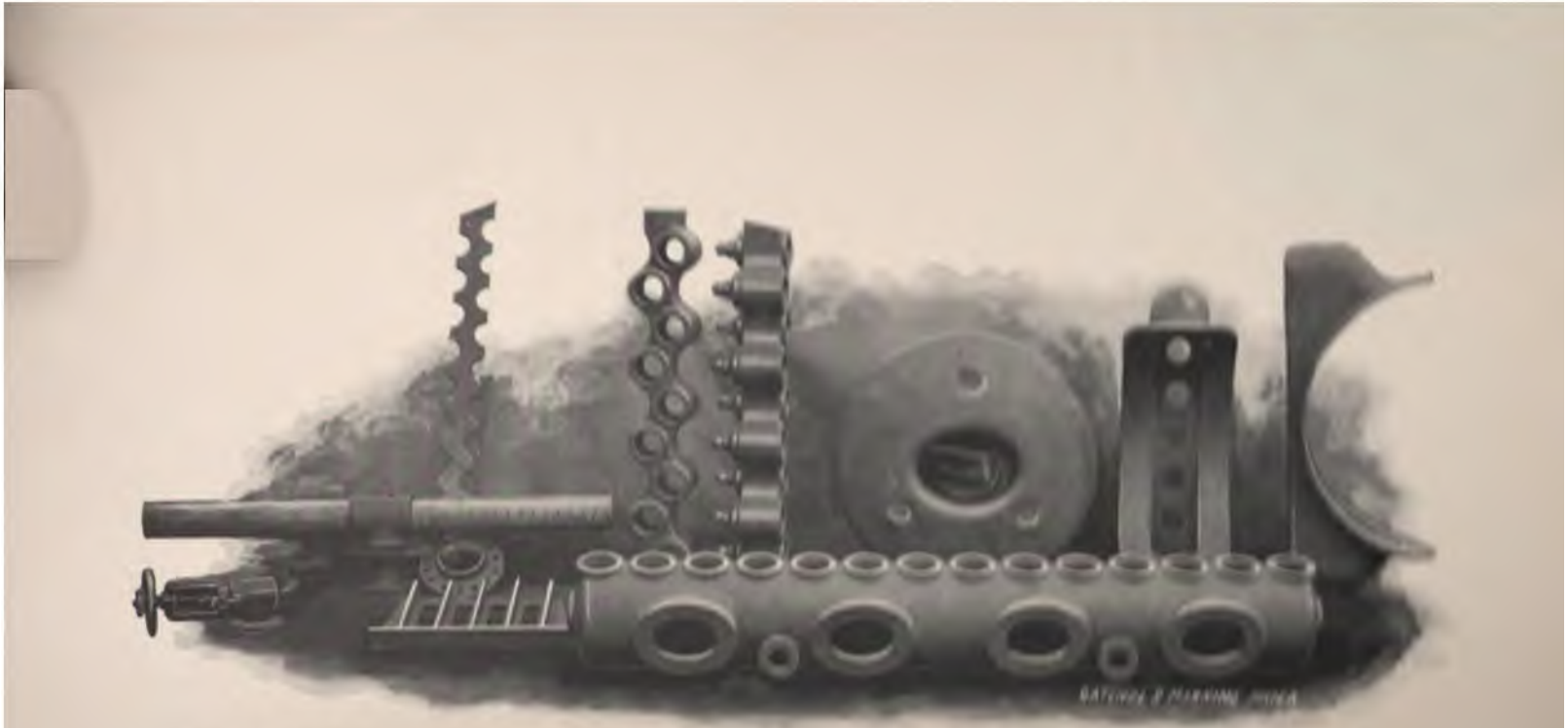
pull or strain or stretch on these corners, which frequently reduces the thickness of the metal in places to the danger point. Moreover, at the ends of the cross-boxes, where the outside nipples go in, the recess inside the cross-box is so shallow that it is impossible to remove a nipple after the boilers are once erected, without tearing down a portion of the brick work to do it. In the Cahall-Babcock & Wilcox boiler, these cross-boxes are made from open hearth steel, which is melted and run into molds, making what we have termed "flowed" steel. This steel, after cooling and annealing, presents all the chemical and physical properties of regular boiler plate steel, physical tests on a large number of coupons from these forms showing an elongation of over 25 per cent., a reduction in area of over 50 per cent., with a tensile strength of over 60,000 pounds to the square inch. Manufacturing the cross-boxes under this process allows any thickness of metal desired at all points in the cross-box where it is most desirable, and moreover, permits making sufficient depth in the cross-box to make renewals or repairs of connecting nipples, without interfering with any other portion of the boiler. This is a feature that is bound to become recognized as one of great value within a few years, when the troubles that are certain to arise from the use of forged steel cross-boxes and headers become more generally known.

The steam drums in their entirety are made of the very best of materials, and the workmanship is exact, everything being done to templates, and all parts fitting to a hair's breadth before the drums are even tested.

As will be seen from the illustrations, the headers or manifolds into which the tubes are expanded, are of the standard sinuous type. These headers are made of a special mix of cast iron. The Aultman & Taylor Machinery Company have been building steam engines and other machinery requiring very intricate and delicate castings for nearly thirty

MANIFOLD OR HEADER WITH HAND HOLE CAP, SAFETY GUARD, BOLT AND NUT, AS USED WITH "CAHALL" BABCOCK & WILCOX BOILERS.

years, and have a most thorough knowledge of the best mixes of iron to accomplish given results. To secure the best effects with these headers the mix must be a tough, close-grained iron, and the mix that we use for this purpose shows a tensile strength of nearly 25 per cent. higher than that used heretofore in the manufacture of headers of this type, as shown by actual hydraulic stress applied in numerous instances. We also make these headers about 25 pounds heavier than has been customary with other manufacturers of these boilers in the past, and distribute this additional weight almost entirely in the form of fillets where sharp corners have heretofore been allowed. There are no sharp corners permitted in the headers of our manufacture, every corner being filled out to a perfect curve by the use of these fillets. The result is, that while cast iron headers as heretofore made will break at an applied pressure of from 1400 to 1600 lbs. to the square inch in nearly all cases, we repeatedly subject those made at our works to a pressure of 2000 lbs. to the square inch without any sign of rupture. The holes in these headers for the reception of the tubes and into which the tubes are expanded, have in other makes of Babcock & Wilcox Boilers been generally left rough as they come from the sand. As it is impossible to get a perfect seat in this way, leaky joints have been very frequent. We have designed a special tool for reaming all these holes to an absolutely perfect seat, preventing the possibility of this leakage ever occurring. The seats on the opposite side of the manifold covered by the hand hole caps for access to the tubes after the boiler is erected, are cut down and milled to a perfect face and the caps which fit over these are also milled and smooth finished, so that when they are put in position they make a steam and water tight joint without the intervention of packing of any kind. The hand hole guards which go inside these hand hole plates, to which the bolt for fastening the hand hole plates in position is fastened, are

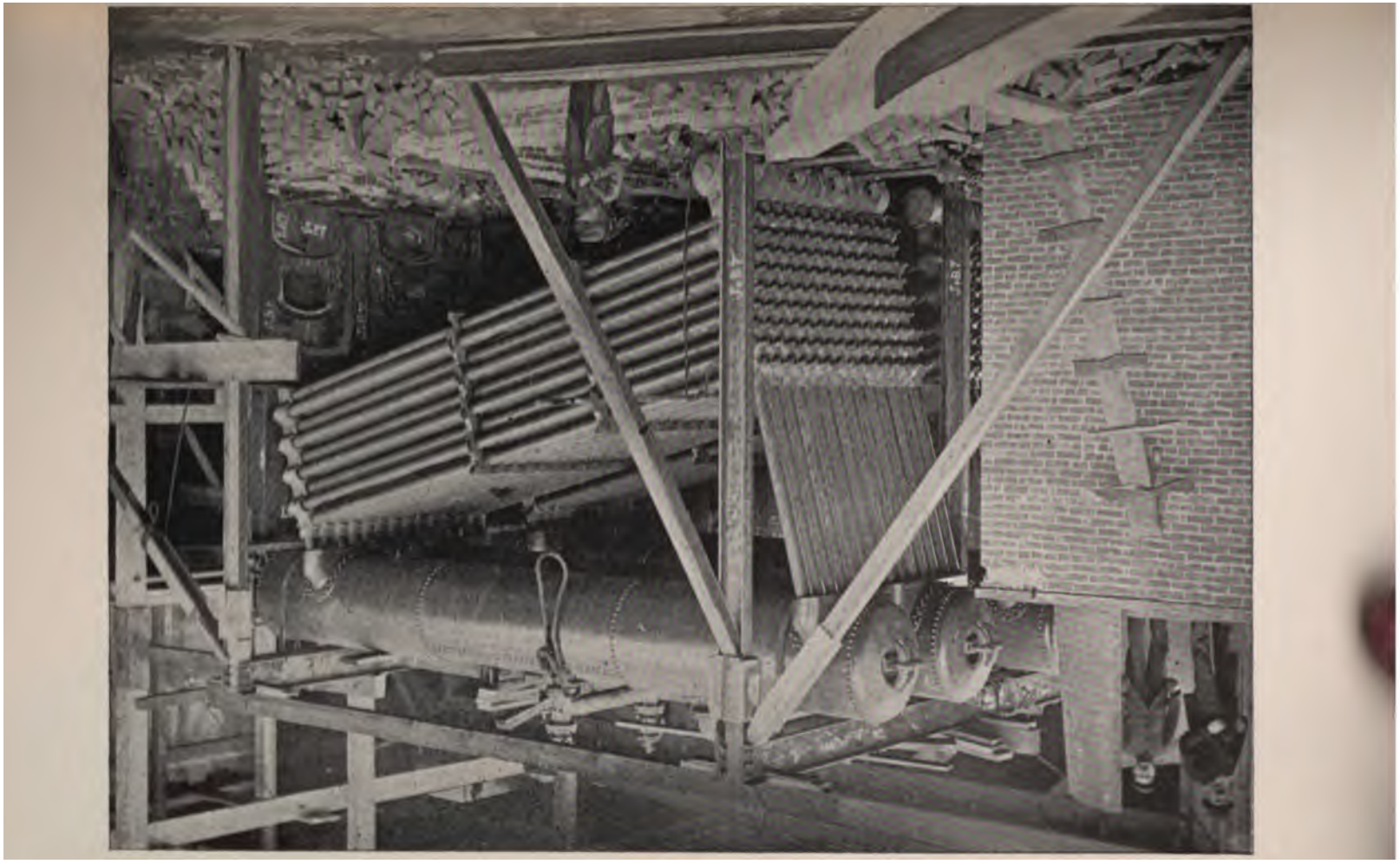


CROSS BOXES, HEADERS, MUD DRUM AND MINOR PARTS OF "CAHALL" BABCOCK & WILCOX BOILERS.

made of malleable iron castings and are elliptical in form, so that they cover almost entirely the inside of the hand hole. This is done as a safeguard, so that in case a bolt fastening the hand hole plate in position should break from any cause, there can be no sudden rush of steam or water through the hand hole, which has frequently occurred with considerable damage to men and property. The bolts used for fastening these hand hole caps in place are of the very best iron, 1 inch in thickness. It can be seen from the side view of the boiler that it stands on wrought iron supports and cross beams, independent of the brick work, so that the entire structure is free to contract and expand without any strains occurring either on the setting or on the boiler itself. In our method of suspension, we have our entire frame work outside of the brick work, thereby avoiding the possibility of its burning away or weakening through overheating, as has been frequently done in the case of other makes.

The fronts for the boiler are what is known as the wrought iron style—that is, the entire general frame work of the front is made up of wrought iron or steel beams, channels and girders, and only the panels containing the door frames are cast. This permits of a very light but rigid structure, which it is impossible to crack from the application of internal heat, which has been heretofore one of the greatest faults found with this type of boiler.

All the tubes used in this boiler are made of the best knobbled charcoal iron, which though very much more expensive than the standard iron boiler tube, yet repays the customer in future years for the additional investment in first cost. The general fittings and trimmings of the boiler are of the highest grade purchasable, the safety valves being of the solid nickel seated type. The water column used is either the Reliance or Pittsburgh High and Low Water Alarm. The blow-off valves are specially made under patents owned by the Aultman & Taylor Machinery Co.,



and are so designed that the discs are renewable at any time and both the disc and valve seat can be cleaned without taking the valve apart.

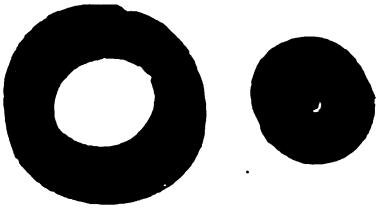
It will be noticed in the illustration giving the rear view of the boiler that these valves have two wheels, one directly above the other, the upper one being smaller than the lower. The larger wheel forces the disc down on its seat, the smaller wheel revolves the spindle carrying the disc. By revolving the larger wheel until the disc rests lightly on its seat and then revolving the smaller wheel, the disc is rotated on its seat, effectually clearing it from any obstructions that may have accumulated thereon.

The side cleaning doors for the boiler are of a new design, which permits the use of only one door instead of two, and when the door is opened it is thrown back entirely from the slot into which it fits, leaving a full, free opening for the introduction of the steam hose, and when the door is closed wedge-shaped fire brick tile, which line the door, are pushed forward in a straight line into the opening, making a perfectly smooth wall on the inside and an absolutely tight joint against the leakage of air into the setting.

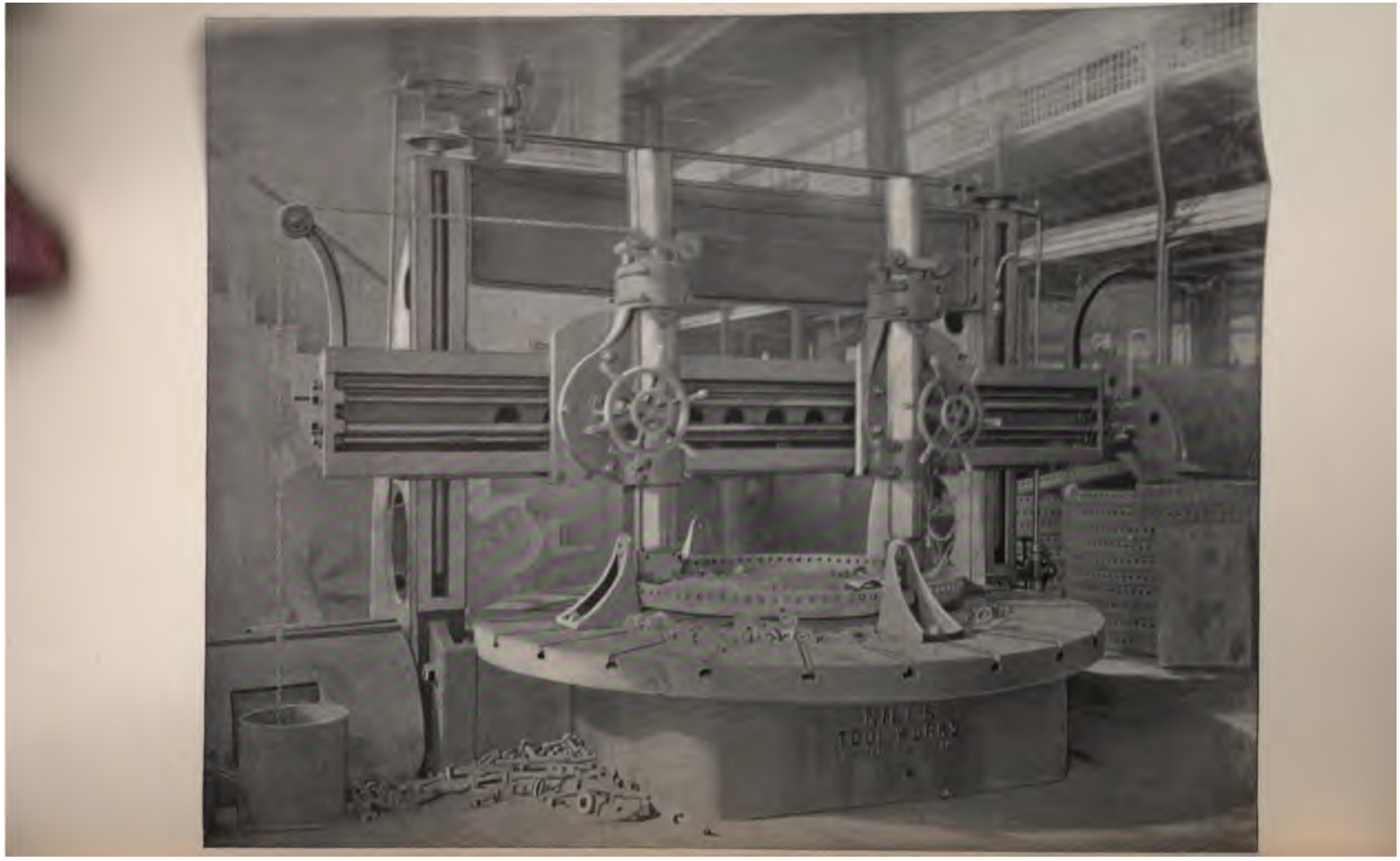
Where very high pressures are to be used, say in excess of 225 pounds to the square inch, the headers or manifolds for the reception of the tubes are made of the same material used in the cross-boxes on the drums, viz., special "flowed" steel.

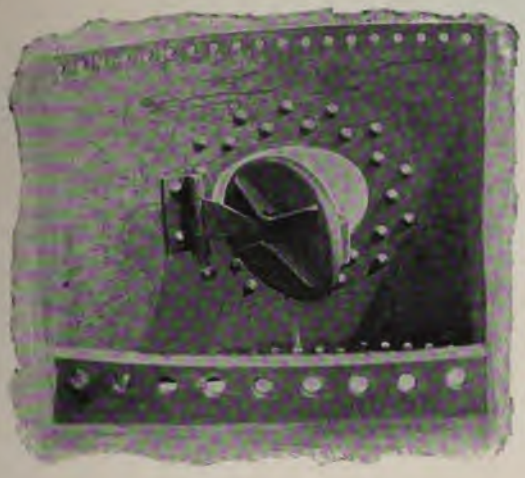
PIECE PUNCHED from "Flowed" steel cross-box.

Same hammered cold to one-fourth its original thickness.



Washer punched cold from same after hammering.

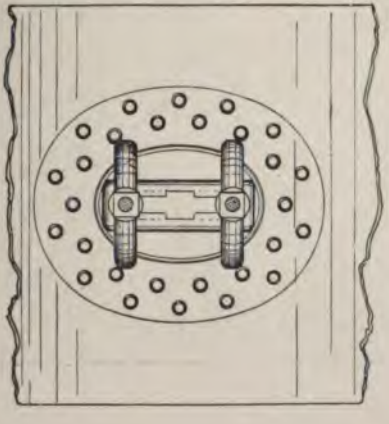




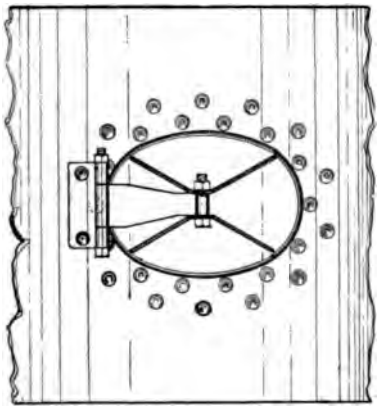
"CAHALL" SWINGING MAN-HEAD.

(Patented.)

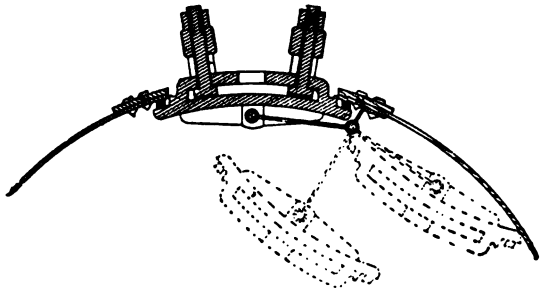
The patent man-head used on "Cahall" boiler drums, while a very simple device, yet is something of great importance. Engineers who for years have been annoyed with the laborious and tedious practice of taking man-heads out of boilers and lifting their heavy weight to a place of safety,

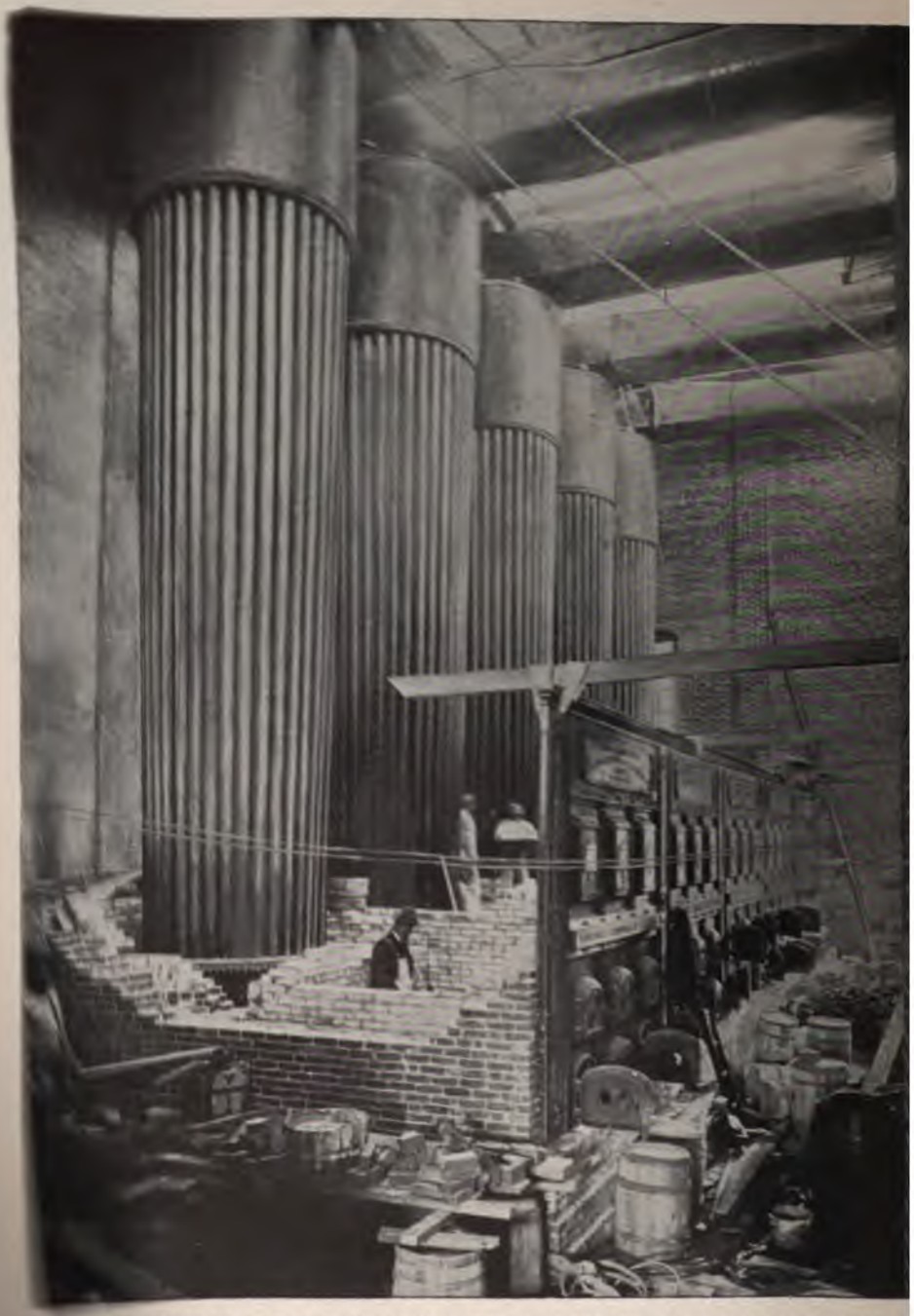


and then putting them back into their places again after the work in the boiler is finished, will appreciate fully the device which is shown in the accompanying cut. By simply loosening the nuts on this man-head, a slight push swings the head in as though it were a door, and it fits back in place against the drum without occupying any appreciable amount of room, and when the time arrives to again close it, it is pulled back to its place. Being hinged, the seats come

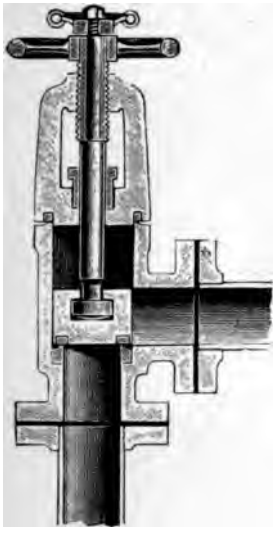


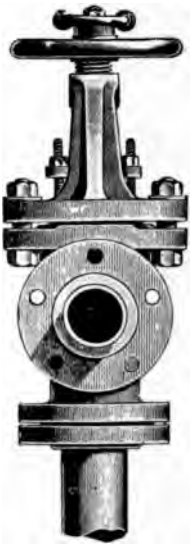
together in exactly the same place every time and the joint being made tight once is tight for all time; less than one minute being required to open the man-head and close it again perfectly tight.





AND SUBURBAN TRACTION CO.'S POWER HOUSE, LOWELL, MAS
CONTAINS 1,250 H. P. "CAHALL" VERTICAL BOILERS.





MOWRY'S IMPROVED MYERS BLOW-OFF VALVE.

(Patent Applied For.)

On the Ohio and Mississippi rivers for many years the only blow-off valve that could be found to stand the wear and tear due to the great amount of dirt found in the waters of those rivers, was the "Myers" mud valve. The seats in this valve are removable, and if care was exercised in keeping the seat free from scale or iron cuttings or chips of any kind, there was never any leakage through it. We have taken this valve and improved it, by having a double wheel so arranged that the large wheel seats the valve. The smaller wheel rotates the valve on its seat, without either raising or lowering the disc. After the valve has been opened the boiler tender, with the large wheel, just seats the valve, then, reversing his wheel for about an eighth or sixteenth of a turn, revolves the smaller wheel, which cleans

ISAAC HARTER FLOUR MILLS, FOSTORIA, OHIO. CONTAINS 500 H. P. "CAHALL" VERTICAL BOILERS.

off both the valve disc and the ring on which it seats. This renders it impossible to ever force the valve down when any foreign substance lays upon it which would tend to cut the seats were the valves seated firmly with the foreign substance in place.

THE ADVANTAGES OF THE "CAHALL" BOILER.

1. Absolute safety from disastrous explosions, and the total absence of all cast metal in its construction.

2. Accessibility for cleaning, examination and repairs.

3. Special adaptability to situations requiring the use of impure feed water.

4. High pressure, every boiler being designed to carry a constant working pressure of 150 lbs.

5. Perfect circulation tending towards preserving uniformity in the temperature in all parts of the boiler, thus doing away with the excessive strains due to the sudden heating and cooling of metals and the consequent loosening of parts.

6. The marked ease with which a tube may be removed and replaced. This feature is in striking contrast to the horizontal type, in which, in case a tube ruptures and gets out of shape, it frequently cannot be withdrawn through the hole in the tube sheet, but must be taken out by cutting away, on the side, above or below, as the case may be, as many tubes as prevent its removal.

7. Economy in fuel, owing to the judicious arrangement of baffle tiling, by which the largest proportion of heat units contained in the gases are utilized in the most efficient manner, and the gases permitted to leave the boiler at a low temperature—owing also to the provisions that have been made for keeping both the inner and outer heating sur-

MICHIGAN ALKALI WORKS, WYANDOTTE, MICH. USES 3,000 H. P. "CAHALL" VERTICAL BOILERS.

faces clean and free from accumulation of scale on the one hand, and soot and ashes on the other. This also tends to promote the durability and prolong the life of the boiler, as the danger of tubes burning out is reduced to a minimum when they are kept clean both inside and out.

8. Economy in maintenance, due to its extreme simplicity and the ease with which it can be cleaned and the readiness with which defective tubes may be removed and new ones replaced.

TESTS OF "CAHALL" BOILERS.

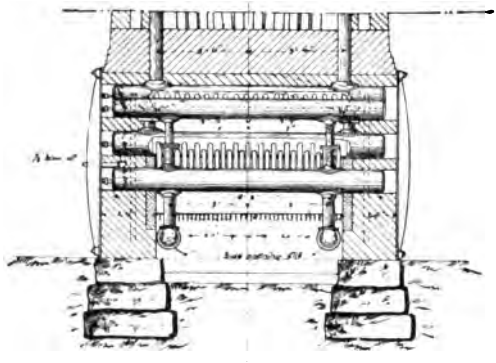
The Armstrong Cork Company, of Pittsburgh, Penna., having in use a 250 horse power Cahall Boiler running in connection with other water tube boilers of a very well known make, wishing to determine the exact performance of their Cahall Boiler, from time to time made, through their own engineers, tests for efficiency and capacity. The results they obtained from their Cahall Boiler in these tests appeared to them too high, being so very much better than anything they had ever been able to secure from the other water tube boilers in use at their works, so arrangements were made to have tests conducted to check theirs, by well known engineers outside of the city. There have been in all nine tests made on this boiler, and we present them herewith.

It will be noticed on test No. 7, the boiler being run at 60% above its rating, showed an efficiency of over 71%, while on test No. 6, the boiler being run only about 3% above its rating, showed an efficiency of nearly 86%, while on test No. 2, with the boiler 11% above rating, the efficiency is nearly 82%. Test No. 5, running 32% above rating, showed an efficiency of 79%.

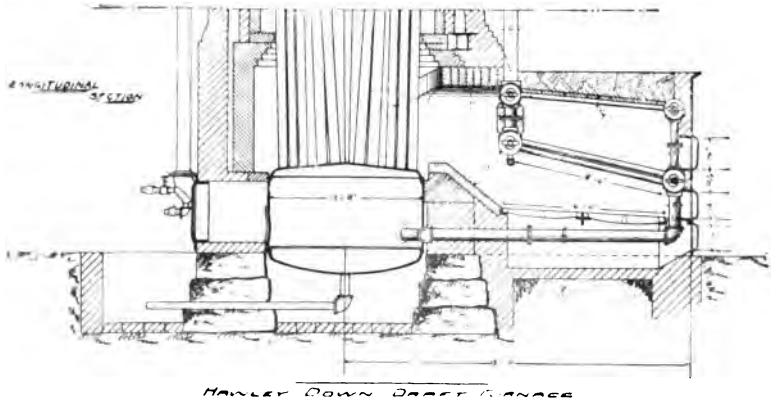
VOIGT BREWERY COMPANY

The nine tests made by different people at different times, with coals that vary in their general composition, extending over a period of eight months, during which time there was never a tube in the boiler scraped, show a wonderfully uniform series of results; the efficiency bearing almost a direct fixed ratio to the capacity in every test; the minimum efficiency being about 70% with the boiler driven at double its rating, the maximum over 85% with the boiler at about its normal horse power.

"CAHALL" BOILER HOUSE, ARMSTRONG CORK CO.



FRONT VIEW
SECTION THROUGH FURNACE



LONGITUDINAL SECTION

HANLEY DOWN DRAFT FURNACE
ATTACHED TO
CAHALL BOILER

OF NINE T CAHALL ARMSTRON PA.	7 By Thos. Pray, Jr., of Boston. (Capacity.)	8 By J. M. Whitham, of Philadelphia, Pa. (Economy.)	9 By J. M. Whitham, of Philadelphia, Pa. (Capacity.)	AVERAGE.
.....	May 5, 1896.	Aug. 11, 1896.	Aug. 12, 1896.	
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essure of St	100.58	97.4	103	98.8
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n in boiler ...	329.5	.....	.....	334.2
of coal).....	Slack, Summer Hill.	Sandy Creek, N. Y. & C. Gas.	Sandy Creek, N. Y. & C. Gas.	
	$0.95	$1.00	$1.00	$1.01
ton of 2,000	13,850	.....	.....	12,963.5
power by Ca	12,893	11,561	17,595	10,132.8
antity consu	1,614	1,148	1,617	975.06
h, clinkers an	12.774	10.4	9.5	9.69
ion of ash, &c	11,021.14	9,864	15,406	8,961.94
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ually consum	1,403.9	.....	.....	1,190.29
tible actually	1,224.59	.....	.....	1,082.79
ft. grate surfa	40.112	24.6 and 11.6	45.6 and 21.4	31.03
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ft. heating su	.61722	.....	.....	.47
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	107,234	99,176	147,411	86,199.08
ount appare	1.1871	.....	.....	1.20
of evaporatio				
ent evaporati	129,130	116,533	173,133	103,007.73
° F.....				
Evaporation	8.6094	9.02	8.66	8.735
ctually evap	**10.22**	**10.58**	**10.17**	**10.43**
ent from and				
nd of combu	.....	.....	.....	9.1106
l.....	11.717	11.81	11.24	11.5869
ent from and				
n per Hour	.....	.....	.....	10,448.57
ctually evap	14,348	9,711	17,313	12,582.82
ent from and				
t. heating su	.....	.....	.....	4.03
.....	6.308	3.69	6.58	4.9571
ent from and				
ft. grate su	.....	.....	.....	298.53
.....	409.94	260.5 and 122.6	463 and 218	320.68
ent from and				
ge of total	**71.259**	.....	.....	**77.867**
ncy.....	.....	.....	.....	19,858.47
aporated pe	.....	.0472	.0492	.0498
vaporating	.....	.....	.....	3.35
sumed per h	.....	.....	.....	.001724
ame.....				
er:				
developed	416.055	281.5	501.8	364.708
ated per ho	250.0	250.0	250.0	250.0
cial rating..				
on capacity	**166.422**	**112.76**	**200.7**	**145.859**
.....				
surface req	5.9945	9.33	5.24	7.3602
.....				

Tests made by THOS. PRAY, JR., BOSTON, MASS.

[CASE 3665.]

Cahall Boiler 250 Horse Power (maker's rating), with Hawley Down Draft Furnace, at Armstrong Cork Co.'s Works, Twenty-fourth and Railroad Streets, Pittsburgh.

1	Date of Trial, May 4th, 1896.	
2	Duration 8.00 A. M. to 5.00 P. M. (no noon hour)	9 hours.

Dimensions and Proportions.

3	Grate surface, 7 feet x 5 feet	35. sq. feet.
4	Water heating surface	2,494. " "
5	Superheating surface	140. " "
6	Ratio of water heating to one of grate surface	71.257

Average Pressures.

7	Pressure by gauge	96.39 pounds.
7a	Error of water column	12.592 "
7b	Correct steam gauge pressure	83.798 "
8	Absolute pressure	98.73 "
9	Barometer, (U. S. Signal Service)	30.4 inches.
9a	Atmospheric pressure	14.932 pounds.
10	Force of draft in inches of water	.6 inches.

Average Temperatures.

11	External air	71. °F.
12	Fire room	93. °F.
13	The steam, 98.730 pounds absolute	326.6 °F.
14	Escaping gases	403.05°F.
15	Feed water	68. °F.

Fuel.

16	Total amount of coal from the pile	7,138. pounds.
17	Percentage of moisture in the coal	2.0134 per cent
17a	Pounds of moisture in the coal	143.72 pounds.
18	Dry coal in pounds	6,994.28 "
19	Ash and cinders	1,271.5 "

CRYSTAL ICE CO.
CATERER.

19a	Percentage of ash and cinders	18.18	per cent
19b	Pounds of moisture, ash and cinders	1,415.22	pounds.
19c	Total loss in coal from all causes	19.827	per cent
20	Pounds of combustible	5,722.78	lbs.
21	Dry coal consumed per hour	777.14	"
22	Combustible consumed per hour	635.86	"

Results of Calorimetric Tests.

23	Quality of the steam (dry steam being taken as unity)	1.02184	
24	Percentage of moisture in steam	0.0000000	
25	Number of degrees superheat	40.238°F.	
25a	Percentage of superheat	2.184	per cent

Water.

26	Total quantity of water pumped into the boiler, and apparently evaporated	65,949	lbs.
27	Water actually evaporated, corrected for quality of steam	67,388	"
28	Equivalent water evaporated into dry steam at and from 212° F	79,936	"
28a	Factor of evaporation	1.1862	"
29	Equivalent B. T. U. from the fuel	77,194,000	B. T. U.
30	" water evaporated into dry steam at and from 212° F. per hour	8,881.8	lbs.

Economic Evaporation.

31	Water actually evaporated per pound of dry coal, from actual pressure and temperature	**9.6347**	lbs.
32	Equivalent water evaporated per pound of dry coal at and from 212° F	**11.429**	"
33	Equivalent water evaporated per pound combustible at and from 212° F	**13.968**	"

Commercial Evaporation.

34	Equivalent water evaporated per pound of dry coal, with one-sixth refuse, at 70 pounds gauge pressure, from temperature of 100° F	10.126	"

Rate of Combustion.

35.	Dry coal actually burned per sq. ft. of grate surface each hour.....	22.204 lbs.
35a.	Dry coal actually burned per sq. ft. of heating surface.....	.3339 "

Rate of Evaporation.

39.	Water evaporated at and from 212°F. per sq. ft. of heating surface each hour..	3.8159 lbs.
39a.	Water evaporated at and from 212°F. per sq. ft. of grate surface each hour.....	253.76 "

Commercial Horse Power.

43.	Horse power of boiler per American Society of Mechanical Engineers' code	**257.55** H. P.
44.	Horse power of boiler (builder's rating) 10 sq. ft. per horse power.....	**250.** "
45.	Horse power in excess of maker's rating in the performance of the boiler....	**3.02** per cent.
45a.	Sq. ft. of heating surface for one horse power.....	9.0374
45b.	Sq. ft. of grate surface for one horse power.....	.1359

Efficiency.

46.	Heat units accounted for in the water for one lb. of dry coal.....	11,037 B. T. U.
47.	Heat units in one lb. of coal by the "Bomb Calorimeter,".....	12,854 "
48.	Efficiency of boiler performance in percentage of the theoretical value of the coal as above.....	**85.862** per cent
49.	Cost of coal per ton (2,000 lbs).....	95. cents.
50.	Possible evaporation for one lb. of coal, actual conditions.....	11.2214 lbs.
50a.	Actual evaporation under working conditions. (See item 31).....	9.6347 "
51	Percentage of possible evaporation realized under actual conditions.....	85.862 per cent
52	Heat units in one ton of coal.....	25,708,000 B. T. U.
53	Heat units required to make one ton of water into steam, actual conditions..	2.291,000 "

1,200 H.P. "CAHALL" VERTICAL BOILERS DURING ERECTION AT PHILADE
COMPANY'S NATURAL GAS PUMPING STATION, PITTSBURGH, PA.

54	Possible tons of water into steam with a ton of dry coal	11.2214 tons.
55	Cost of 2,000 lbs. of water into steam, actual conditions	8.4661 cents.
56	Pounds of water into steam for one cent, actual conditions	236.24 lbs.
57	Horse powers of 34.488 lbs. of water per hour at and from 212° F., A. S. M. E. code or its equivalent, 30 lbs., from 100° F., to 70 lbs. steam gauge pressure, for one cent	6.8503 H. P.
58	Cost of one horse power of steam one hour, in fractions of a cent	.146
59	Heat units for one cent	270,620 B. T. U.
60	Theoretical loss of possible heat units, all sources	14.138 per cent

[SIGNED.]

THOMAS PRAY, JR.

[CASE 3666.]

Cahall Boiler 250 Horse Power (maker's rating), with Hawley Down Draft Furnace, at Armstrong Cork Co.'s Works, Twenty-fourth and Railroad Streets, Pittsburgh.

1	Date of trial, May 5th, 1896.	
2	Duration, 8.00 A. M. to 5.00 P. M. (no noon hour)	9 hours.

Dimensions and Proportions.

3	Square feet of grate surface 5 feet long by 7 feet wide	35. sq. feet.
4	Water heating surface	2,494. " "
5	Superheating surface	140. " "
6	Ratio of water heating surface to one of grate surface	71.257

Average Pressures.

7	Steam pressure in boiler by gauge	100.58 pounds.
7a	Error of water column	12.592 "
7b	Correct steam gauge pressure	87.988 "

8	Absolute pressure per square inch.....	102.699 pounds.
9	Barometer, (U. S. Signal Service).....	29.95 inch.
9b	Atmospheric pressure in lbs. per square inch	14.711 pounds.
10	Force of draft in inches of water.....	.6324 inch.

Average Temperatures.

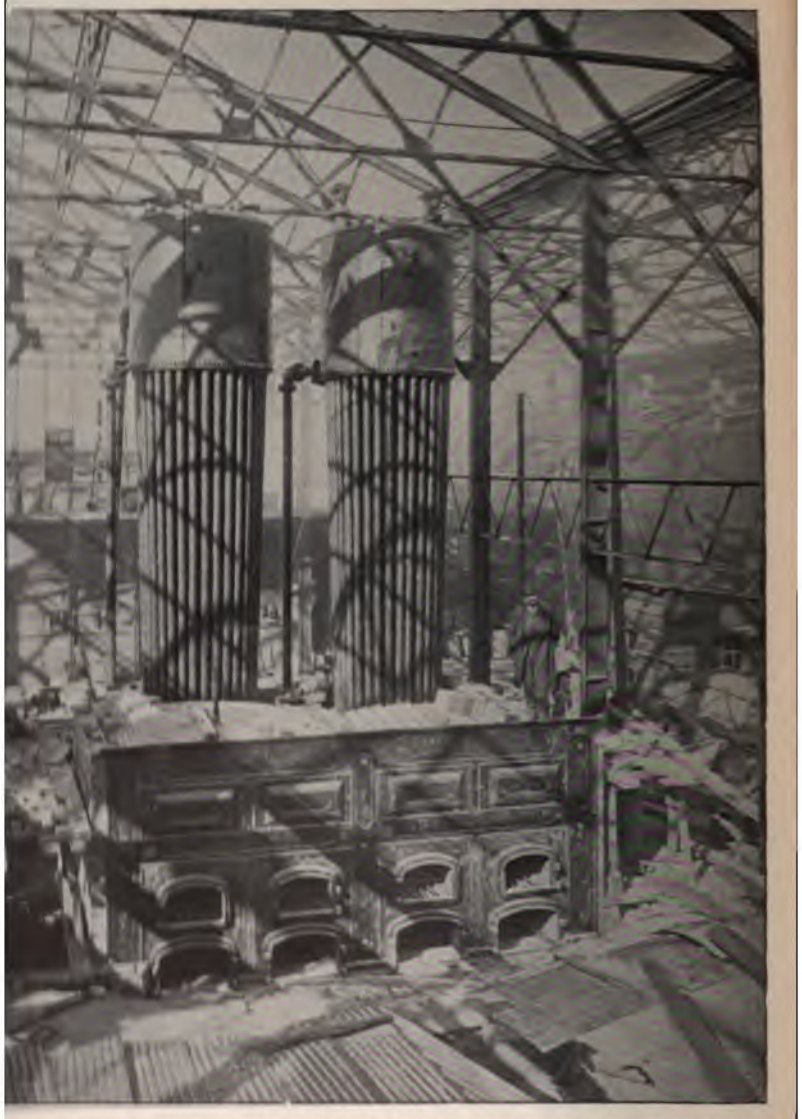
11	Of external air	78.+
12	Of fire room.....	96.+
13	Of the steam at 102.699 lbs. per square inch	329.5 °F.
14	Of escaping gases.....	477.772 "
15	Of the feed water.....	68.2 "

Fuel.

16	Total amount of coal from the pile	12,893. pounds.
17	Moisture in the coal.....	2. per cent.
17a	" " "	257.86 pounds.
18	Dry coal in pounds.....	12,635.14 "
19	Ashes and cinders	1,614. "
19a	" " "	12.774 per cent.
19b	Pounds of moisture, ashes and cinders..	1,871.86 lbs.
19c	Total losses in coal, from all causes.....	14.5188 per cent.
20	Pounds of combustible.....	11,021.14 lbs.
21	Dry coal consumed per hour.....	1,403.9 "
22	Combustible consumed per hour.....	1,224.59 "

Results of Calorimeter Tests.

23	Quality of the steam, dry steam being taken as unity.....	1.01443
24	Moisture in the steam.....	0.000000
25	Number of degrees of superheat.....	26.499
25a	Percentage of superheat.....	1.443
26	Total quantity of water pumped into the boiler and apparently evaporated....	107,234. lbs.
27	Water actually evaporated corrected for the quality of the steam	108,780. "
28	Equivalent water evaporated into dry steam at and from 212° F.....	129,130.
28a	Factor of evaporation.....	1.1871
29	Equivalent British Thermal Units from the fuel..... .....148,030,000.	
30	Equivalent water evaporated into dry steam at and from 212° F. per hour..	14,348



VERTICAL BOILERS AT SICILIAN ASPHALT PAVING CO.'S WORKS, NEW YORK CITY.

Economic Evaporation.

31	Water actually evaporated per pound of dry coal from actual pressure and temperature	**8.6094** lbs.
32	Equivalent water evaporated per pound of dry coal at and from 212° F	**10.22** "
33	Equivalent water evaporated per pound of combustible at and from 212° F	**11.717** "

Commercial Evaporation.

34	Equivalent water evaporated per pound of dry coal with one-sixth refuse at 70 lbs. gauge pressure, from temperature of 100° F	8.4936 lbs.

Rate of Combustion.

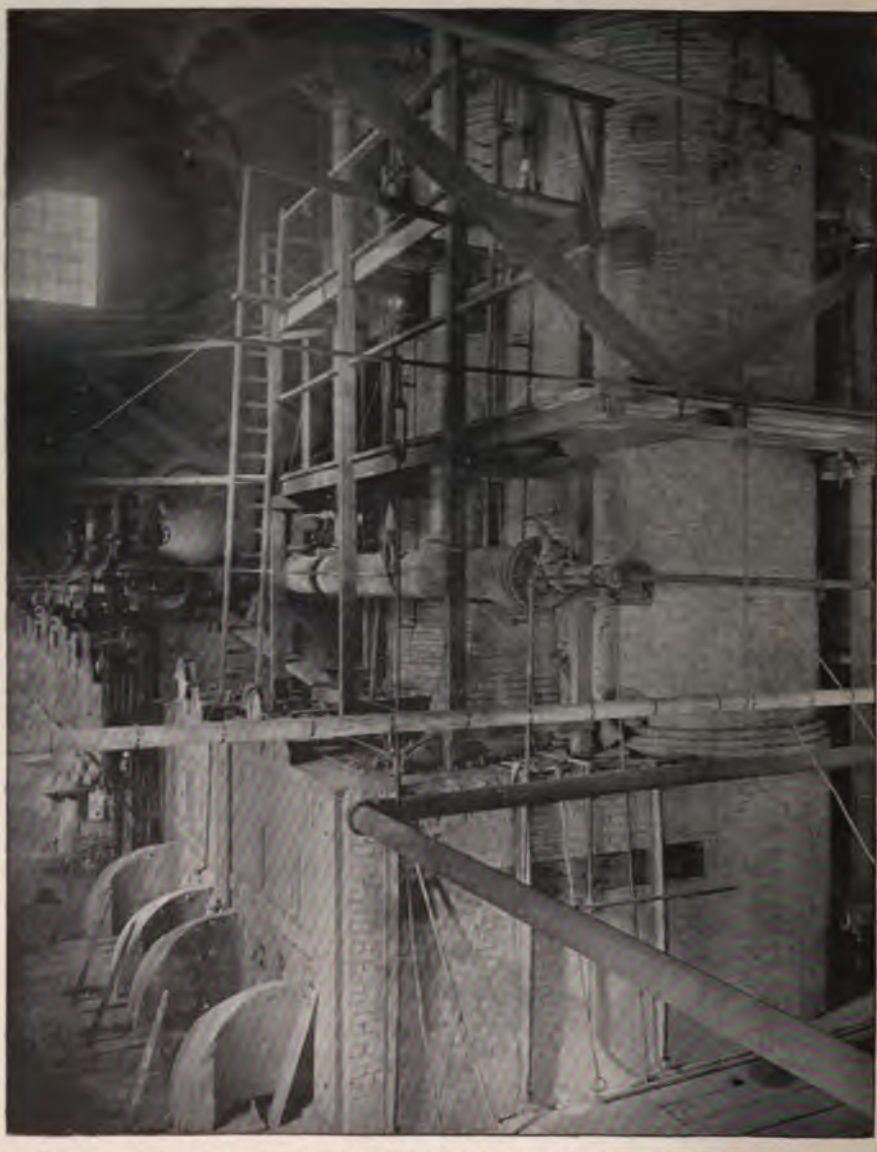
35	Dry coal actually burned per sq. ft. of grate surface each hour	40.112 lbs
35a	Dry coal actually burned per sq. ft. of heating surface each hour	61.722 "

Rate of Evaporation.

39	Water evaporated at and from 212° F per sq. ft. of heating surface each hour	6.308 lbs.
39a	Water evaporated at and from 212° F. per sq. ft. of grate surface each hour	409.94 "

Commercial Evaporation.

43	Horse Power of boiler per American Society of Mechanical Engineers' code on basis of thirty pounds of water per hour evaporated from temperature of 100°F. into steam of 70 lbs. gauge pressure = 34.5 lbs., from and at 212° F	**416.055**
44	Horse Power of boiler (builder's rating), 10 sq. ft. of heating surface per horse power	**250.** H. P.
45	Excess of maker's rating in the performance of the boiler	**66.422** per cent.
45a	Square feet of heating surface for one horse power	5.9945 sq. ft.
45b	Square feet of grate surface for one horse power	.084318 "



"CAHALL" VERTICAL WATER TUBE BOILERS BLAST FURNACE GAS FUEL AT JOLIET WORKS OF THE ILLINOIS STEEL CO.

Efficiency.

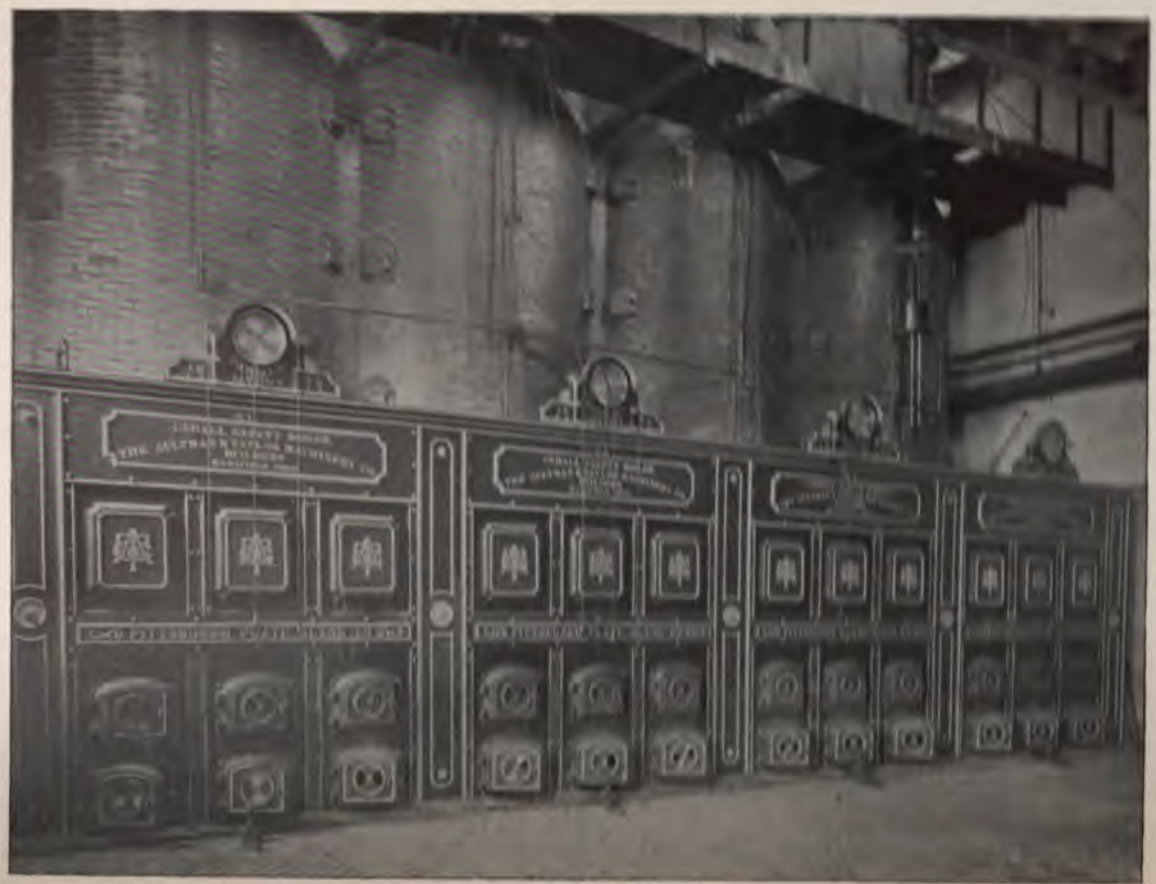
46	Heat units accounted for in the water for one pound of dry coal	9,869.	B. T. U.
47	Heat units in one pound of coal by the calorimeter (3 tests)	13,850.	"
48	Efficiency of boiler performance in percentage of theoretical value of the coal as above	**71.259**	per cent.
49	Cost of coal per ton (2,000 lbs.)	95.	cents.
50	Possible evaporation per pound of coal, actual conditions	12.082	pounds.
50a	Actual evaporation under working conditions (See item 31)	8.6094	"
51	Percentage of possible evaporation realized under actual conditions	71.259	
52	Heat units in one ton of coal (2,000 pounds)	27,700,000.	B. T. U.
53	Heat units required to make one ton of water into steam, actual conditions	2,292,740.	"
54	Possible tons of water into steam with a ton of dry coal	12.082	tons.
55	Cost of 2,000 pounds of water into steam	7.863+	cents.
56	Pounds of water into steam for one cent	254.35	pounds.
57	Horse power of 34.488 pounds of water per hour at and from 212°F., A. S. M. E. Code, or its equivalent 30 lbs. from 100° F. to 70 lbs. Steam Gauge Pressure for one cent	7.3758	H. P.
58	Cost of one horse power of steam one hour in fractions of one cent	.136	
59	Heat units for one cent	291,582.	B. T. U.
60	Theoretical loss of possible heat all sources	28.741	per cent.

The Bomb Calorimetric results were done for me at Cornell University, and received on May 26th, at which time I was hundreds of miles away on similar work; could not finish the computations sooner.

(SIGNED).

THOMAS PRAY, JR.

Boston, May 14th, 1896.



PORTION OF BOILER ROOM PITTSBURGH PLATE GLASS CO.'S KOKOMO PLANT, CONTAINING 1,500 H. P. "CAHALL" VERTICAL BOILERS.

Final Report and Results of Tests made at Armstrong Cork Company, Pittsburgh, Penna., May 4th and 5th, 1896.

[CASES NOS. 3665 AND 3666.]

Full Report Herewith, as Rendered.

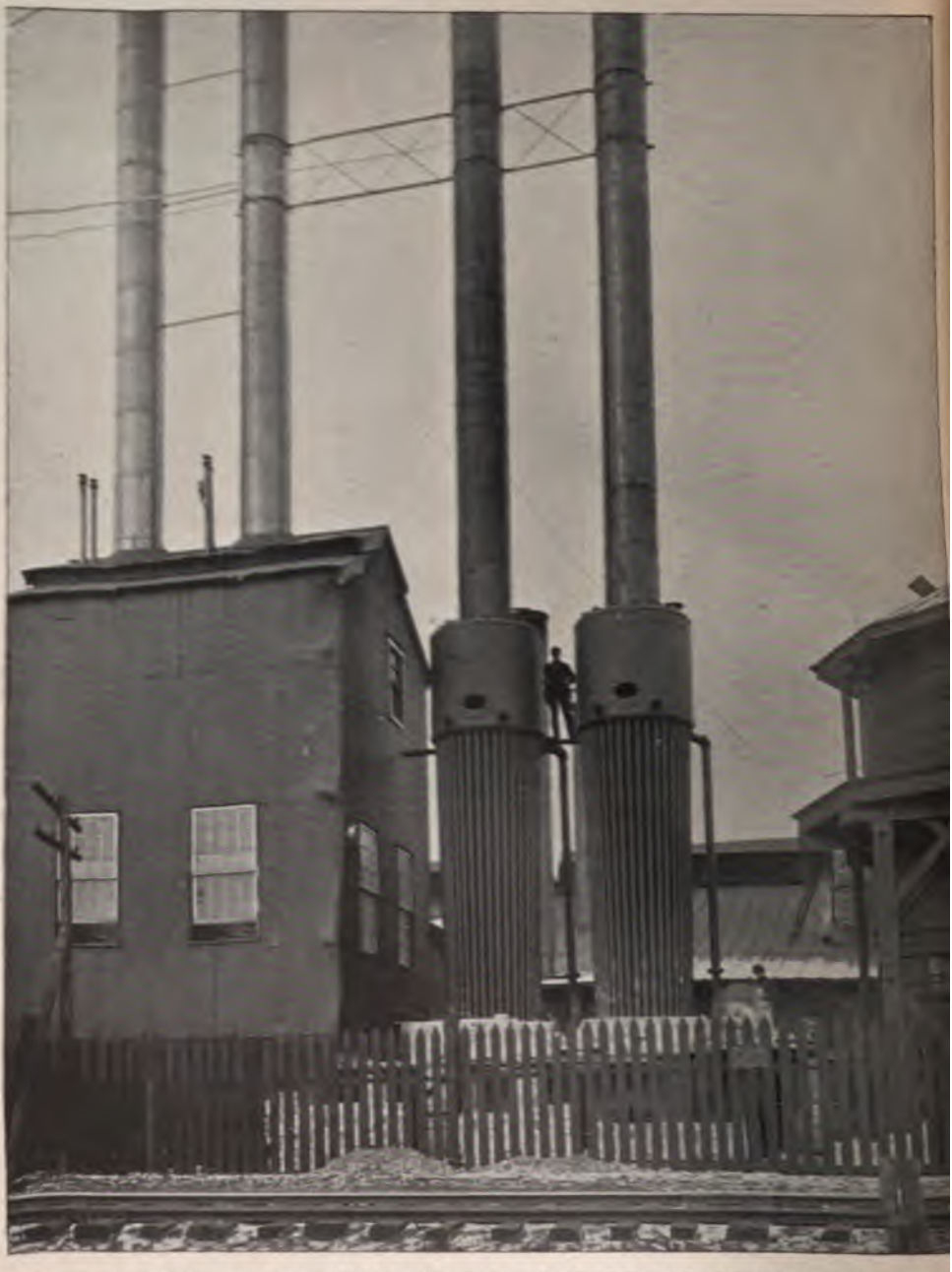
This final report deals only with the Chemical Analyses of Coal used on days as above, and the results as computed by me in my usual practice, Items 46 to 60, inclusive, (these Items are computed strictly with the Code of the A. S. M. E. but are not recognized in that code as it now stands on the Transactions of that Society).

Chemical Analyses were made at the Cornell University for me, and the Determination of the Theoretical British Heat Units in a pound of coal was also made at Cornell.

In the computation of the B. T. U. of coal with so high a percentage of Volatile, the most reliable formulae are sadly at fault, hence I have adopted the "Bomb Calorimeter" determination, in place of some of the so called utterly unreliable "Coal Calorimeters," and in such tests prefer to employ entirely disinterested persons to do this work, than to do it myself, although familiar with the work.

The coal used was sampled from each two hundred pounds and a final sample drawn from this amount and put into a tin can, soldered up in the yard, and sent away to the Chemist each day. The coal was shoveled off the cars in the yard of the Armstrong Co., at various times each day, or as the men had the time to do it.

The test of the Cahall Boiler for capacity, is one of the best I have seen, in over four thousand boilers already tested, without one exception, a boiler rated by builders as 250 horse power, under American Society of Mechanical Engineers' Code, of 34.4876 lbs. of water at and from 212° F., or its equivalent, which calls for the use of 33,305 B. T. U. an hour, whatever the pressure and temperature may be under actual conditions.



1,000 H. P. "CAHALL" VERTICAL BOILERS AT WORKS OF WELLSVILLE PLATE AND SHEET IRON CO., WELLSVILLE, OHIO.

That this boiler did for nine hours easily, and could have done for nine days, *one hundred and sixty-six and four hundred and twenty-two one thousandths* per cent. of that rating, or 416.055 horse powers, with an efficiency of 10.22 pounds of water at and from 212° F. with one pound of *dry coal*, and the fires not managed at their best, is certainly not other than an extraordinary result; no sort of change was made from its usual every day conditions; it was not, as in some similar cases, done with a grate surface cut down, or some other factor changed, but it was an every day test, by the regular fireman of the concern who owned the boiler, and this man ran it to suit himself (it was not a particle of use to suggest to him), and under these conditions, 71.259 per cent. of the possible heat units by laboratory test, were accounted for in the water and steam, the whole day had a superheat in the steam amounting to 1.443 per cent, or 26.499° F. above temperature due to pressure.

I regret not being able to send this final report sooner, but it requires time to do properly the chemical analyses of coal, and in these cases more than one determination of each have been made, the variation between any two is almost immaterial, but the average of three in each case are considered as final.

When the analyses came, I was away, and now improve first day possible to forward you, and am certain that the results will interest steam users who are looking for facts.

All of which is respectfully submitted.

THOMAS PRAY, JR.

BOSTON, June 2d, 1896.

95 *Milk Street, Room* 71.

"CAHALL" VERTICAL WASTE HEAT BOILER AT CHICAGO HORSE SHOE CO.'S WORKS, CHICAGO, ILLS.

Test Made on a Cahall Waste Heat Boiler at the Republic Iron Works, Pittsburgh, Pa., by the Pittsburgh Testing Laboratory. June 2d and 3d, 1893.

DURATION OF TEST.—The test was run from 4.00 P. M. on June 2d to 3.00 A. M. on June 3d (11 hours), which was from charge to charge of furnace. During the last half hour, while they were making new bottoms, no gas was used.

BOILER.—The boiler tested was a Cahall Patent Vertical Water Tube Boiler, having seventy-two 4-inch and six 5-inch tubes, on 1332.4 square feet of heating surface. Diameter of steam drum 60 inches; height, 80 inches; diameter of mud drum, 78 inches; height, 42 inches; diameter of up-take through mud drum, 38 inches. Rated by the makers as 125 horse power.

The boiler was connected with a single re-heating furnace, and used the waste gases as fuel. During the test seven heats were made, and the total weight of the finished iron was 25,300 pounds, being rather more than the amount finished by other furnaces in many works running eight heats.

FUEL.—The fuel used by the re-heating furnace was natural gas.

The following is an analysis of same:

Carbon Di-Oxide	0.7 per cent.
Illuminants	0.2 " "
Oxygen	0.1 " "
Carbon Monoxide	0.5 " "
Hydrogen	None.
Marsh Gas	64.5 per cent.
Nitrogen	34.0 " "
	100.0 per cent.

The large amount of free nitrogen in the gas would account for its rather low efficiency. The heat units per cubic foot of this gas were 682.36 B. T. U.

"CAHALL" VERTICAL BOILER AT SIEMENS & HALSKE ELECTRIC
CHICAGO, ILLS.

The following is the analysis of the coal on which this boiler had been previously run and tested:

Carbon	71.62 per cent
Hydrogen	5.15 " "
Sulphur	.92 " "
Oxygen and Nitrogen	11.51 " "
Ash	10.30 " "
Moisture	.50 " "
	100.00 per cent.

The number of heat units per pound of coal were 13,617.7 B. T. U. Or, theoretically, 20 cubic feet of natural gas used was equal to one pound of this coal, or 40,000 cubic feet equal to one ton. Two analyses were made, which checked with each other, showing that the gas was of the above composition.

The method of firing the furnace was through a manifold, which had seven fingers ¾-inch in diameter, alternating with seven fingers one inch in diameter. The pressure was measured by water gauge, the average pressure being 3.13 inches of water. The amount of gas used was 101,515 cubic feet.

WATER.—The water used was measured in two barrels, first barrel being filled until the tell-tale ceased dripping, when it was emptied into a second barrel and then fed into the boiler with a Mack Injector. The weight of water by scale and by this method we compared and found results to agree within less than a pound. Injector used steam from boiler tested. The total water evaporation was 50,700 pounds. At the start of the test, the height of the water in the water gauge was noted by a band around the gauge. At the close of the test the water was brought to this mark. Analysis made of the gas taken from the stack during the test showed the following results:—

Carbon Di-Oxide	5.90 per cent
Carbon Monoxide	None.
Oxygen	5.30 per cent.
Nitrogen, Sulphur Di-Oxide, Aqueous Vapor,	88.80 " "
	100.00 per cent.

VERTICAL WASTE HEAT BOILER AT INLAND STEEL CO.'
PLANT, CHICAGO HEIGHTS, ILLS.

STEAM PRESSURE.—The steam pressure at the start was 106½ pounds; at the close it was 105 pounds; the average pressure being 104.9 pounds.

CALORIMETER TESTS.—Calorimeter tests were made at intervals through the test, showing, as an average, that the steam was superheated to 73.8° Fahrenheit.

The steam for the calorimeter test was taken from the main steam pipe, at a distance of about eight feet from the boiler. The pipes were not lagged. When the steam was allowed to blow into the air, no condensation was observed for a distance of six feet, clearly showing that the steam was superheated to a high degree.

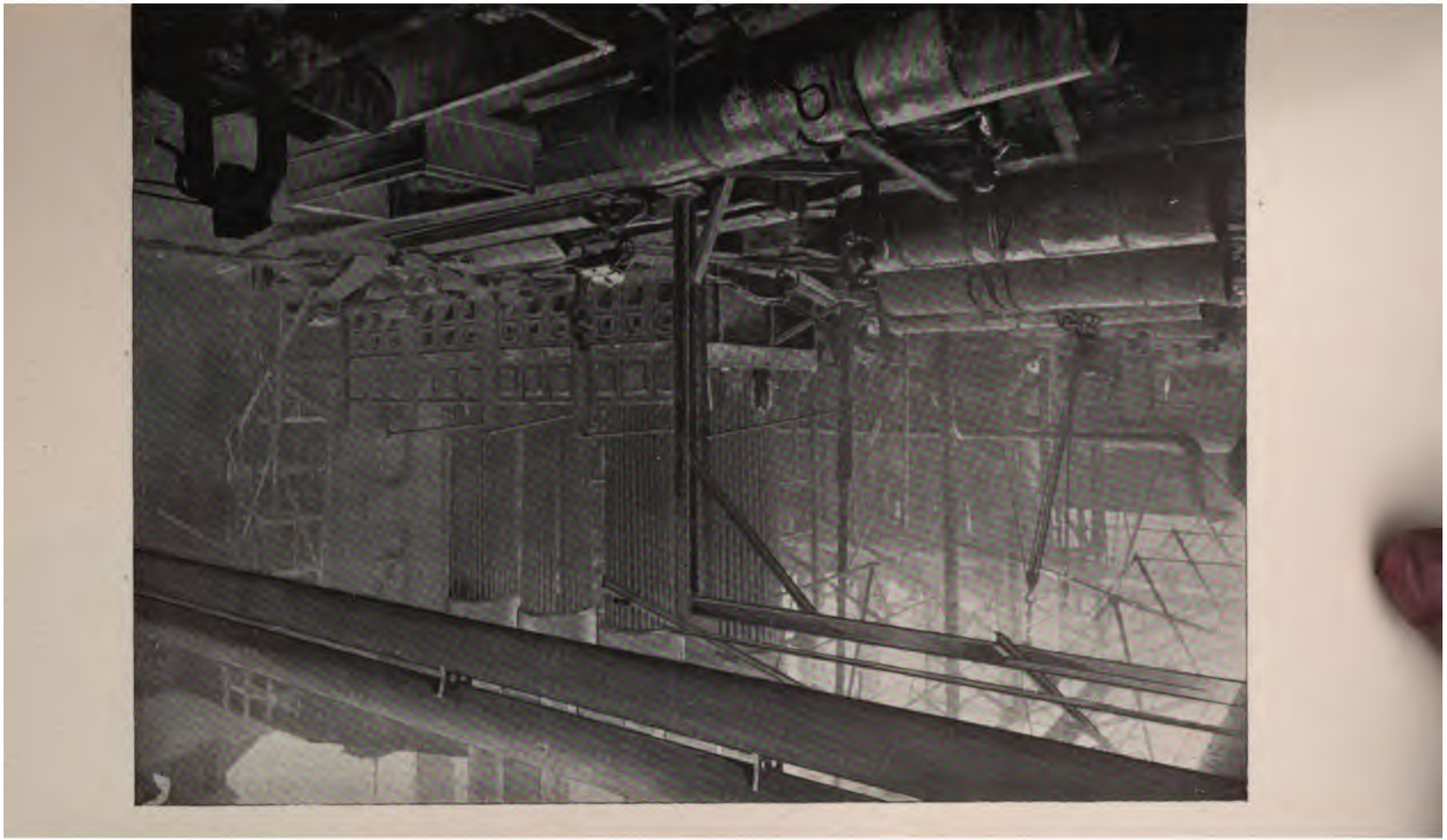
The calorimeter used was an ordinary barrel-calorimeter; the weight of condensing water being about 300 pounds, and the amount of steam condensed being from five to ten pounds. The scales were read within one-eighth of a pound.

CORRECTIONS.—The barometer used was an aneroid, which was corrected by the weather bureau. Thermometers and steam gauge were all tested and corrected before the test.

OBSERVATIONS.—Observations were taken every fifteen minutes during the eleven hours, and the average of these used in the results obtained.

Attached are the complete results of the test. The results show that this boiler is equally adapted to the use of coal or gas. Probably a much better test would have been shown (although this one is in our minds very satisfactory, indeed) if the natural gas used had contained a less percentage of free nitrogen, or the coal a less per cent. of ash. From the rapidity with which this boiler made steam, and from the temperature of the gases in the stack, we think in this particular case the boiler could be of somewhat larger size for this furnace to utilize economically the waste gases.

One of the most notable features about this boiler is the extremely small amount of room which it occupies, taking but little more room than an ordinary stack.



Considering the size, simplicity, low cost, its equal adaptability for coal or gas, and its economical steaming properties, it is without doubt the best boiler for its purposes which has come under our observation, and we recommend it cheerfully for all iron and steel works.

It is interesting to note, in connection with this test, the results in tests by other parties. We know of but very few comparative tests which we have made of the consumption of gas to that of coal under the same boilers, with the conditions as nearly similar as possible. The only comparative tests we know of are those of the Engineers' Society of Western Pennsylvania, and the tests of the Allegheny County Light Company and the Allegheny Gas Works.

The number of cubic feet of gas required to evaporate one pound of water, from and at 212 degrees Fahrenheit, as found by tests at the Allegheny Gas Works, were 1.33, 1.37, 1.39, and 1.78, and those of the Allegheny County Light Company, 1.43, 1.78 and 1.50 cubic feet of gas to evaporate one pound of water, from and at 212 degrees Fahrenheit. Our test showed that to evaporate one pound of water, from and at 212 degrees Fahrenheit, it took 1.686 feet of gas.

It must be borne in mind that on these other tests the gas was burned directly under the boilers and had no other work to do, while in our test the gas first had to heat 25,300 pounds of iron, and that the gas itself had a much less theoretical calorific value.

In a series of tests made by the Fuel Gas & Electrical Engineering Company, theoretically, it required nearly 1,000 cubic feet of gas to evaporate as much water as 55 pounds of coal, or 36,360 cubic feet of gas equal to one ton of coal.

S. A. Ford, of The Edgar Thomson Steel Works, after his long series of well known experiments, determined that 1,000 cubic feet was equivalent to 54.4 pounds of coal, or 36,760 cubic feet of gas equal to one ton of coal; and in our own case, we obtained by analysis that 1,000 cubic feet of gas was equal to 50 pounds of coal, or 40,000 cubic feet of gas equal to one ton of coal. It is thus clear that the quality in this case is much below that commonly used elsewhere.

"CAHALL" VERTICAL BOILERS AT JONES & LAUGHLINS' STEEL W
PITTSBURGH, PA.

From the above it will be seen that this boiler, using the waste gases from a re-heating furnace, is very nearly equivalent to the other boilers noted, which burned the gas directly underneath them.

This is no doubt due to the fact that they are not so well adapted to the use of gas as fuel, as the Cahall Boiler. This is only natural, as the best results are obtained with long tubular or return tubular boilers, for in case of short boilers there is too little space between the flues, and between the flues and top shell—that is, they get very little advantage from the waste gases; and no doubt if a pyrometer test had been made of the escape gases in the tests noted above, a very high temperature would have been shown.

DESCRIPTION OF BOILER—One 125 Horse Power Cahall Vertical Water Tube Boiler; diameter of Steam Drum 60 inches; height 80 inches; diameter of Mud Drum 78 inches; height 42 inches; diameter of Up-take through Mud Drum 38 inches; number and diameter of Flues 72, 4 inch and 6, 5 inch. Duration of test 11 hours.

Square feet of heating surface	1332.4
Kind of fuel used, (analysis given)	Natural Gas.
Cubic feet of gas	101,515.
Cubic feet of gas per hour	9228.6
Average steam gauge pressure	104.9 lbs.
" " absolute pressure	119.34 "
" draft pressure, inches of water	0.40 ins.
" gas " " " "	3.13 "
" Barometer 29 4" =	14.43 lbs.
" temperature of feed water	71.16° F.
" " " outside air	86.6° "
" " " boiler room	100.1° "
Quality of steam, dry taken as unity, (Superheat)	73.8° "
Pounds of water evaporated (actual conditions)	50,700
" " " " " per hour	4609.1
Pounds of water evaporated (actual conditions) per 1000 cu. ft. of gas	499.32
Pounds of water evaporated (actual conditions) per 1 cu. ft. of gas	0.4993
Pounds of water evaporated from and at 212° F. per 1000 cu. ft. of gas	592.79

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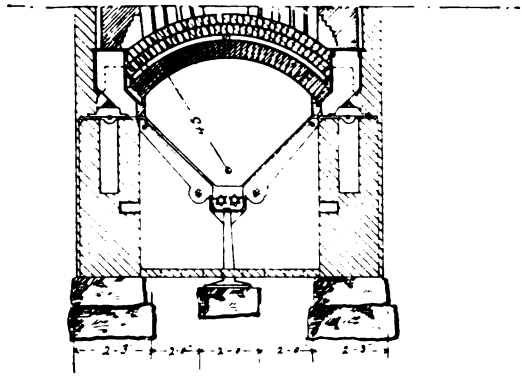
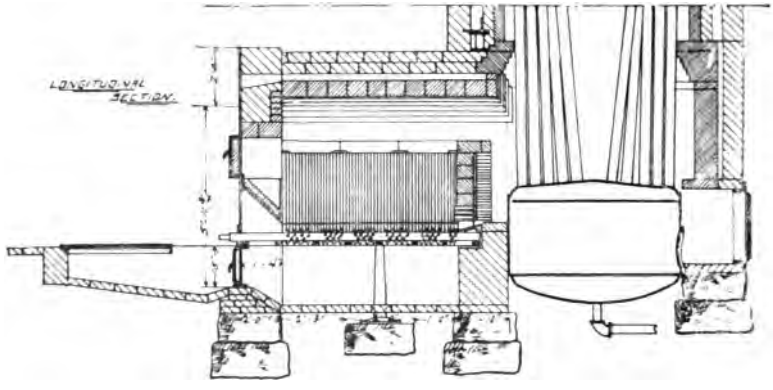
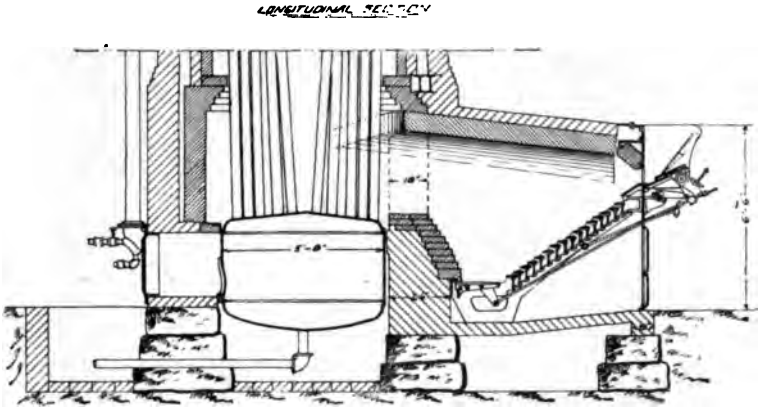


FRONT ELEV
SECTION THROUGH FURNACE



MURPHY SMOKELESS FURNACE
ATTACHED TO
CAHALL BOILER
150 HP

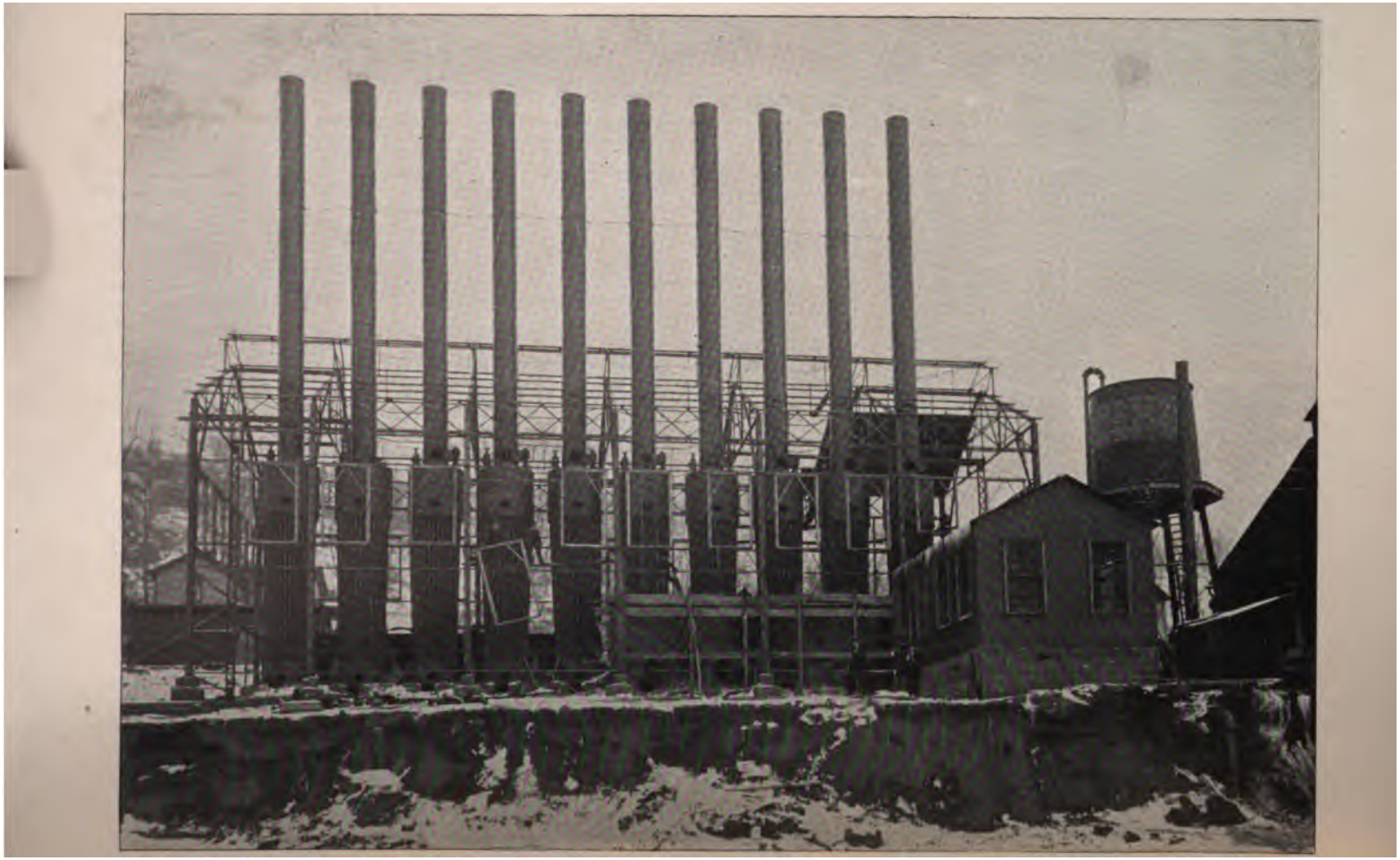
Pounds of water evaporated from and at 212° F. per 1 cu. ft. of gas	0.593
Cu. ft. of gas required to evaporate 1 lb. of water (actual conditions)	2.002
Cu. ft. of gas required to evaporate 1 lb. of water from and at 212° F	1.686
Pounds of water evaporated, actual conditions, per 1 lb. of combustibles, by analysis, equivalent of gas	9.989
Pounds of water evaporated, from and at 212° F., per 1 lb. of combustibles, by analysis, equivalent of gas	11.859
Pounds of water evaporated per sq. ft. heating surface per hour	3.46
Horse power actually developed	153.64
Horse power from and at 212° F	182.41
Centennial Standard	158.6
Rated	125.00
Per cent. above rated capacity, actual	22.91
" " " " Centennial	26.88
Sq. ft. of heating surface per horse power, actual	8.67
" " " " " " " Centennial	8.40



ROney MECHANICAL STOKER
ATTACHED TO
CAHALL BOILER
250 HP

SUMMARY OF 21 TESTS MADE ON "CAHALL" VERTICAL BOILERS.

LOCATION.	DATE.	ENGINEER.	Rating.	H. P. developed.	Duration of test in hours.	Evaporation per lb. combustible from and at 212° F.	Moisture in steam per cent.	Superheat in steam Deg. F.	Per cent. developed. Above Rating.	Per cent. developed. Below Rating.	KIND OF FUEL.
Aultman & Taylor, Mansfield, O.....	Oct. 1, 1892...	R. B. Day	55	81.5	8.00	11.30	.....	12.0	50.5	.....	Pittsburgh Run of Mine.
Republic Iron Works, Pittsburgh, Pa.	June 2-3, 1893.	Pgh. Testing Laboratory	125	158.6	11.00	11.85	.....	73.8	26.8	.....	Natural gas.
Sharon Iron Co., Sharon, Pa.....	April 26, 1895.	A. B. Bellows.....	200	200.5	10.00	11.28	1.32	.....	.25	.....	Blast Fur. gas and slack.
Salem Iron Co., Leetonia, Ohio	May 10, 1895.	"	250	259.5	10.00	12.92	.40	.....	3.8	.....	" " " " Cherry Val. slack
Michigan Alkali Co., Wyandotte, Mich	Aug. 16, 1895.	R. B. Day.....	500	625.2	8.00	10.74	.....	6.0	25.0	.....	Bituminous slack.
Armstrong Cork Co., Pittsburgh, Pa...	Jan. 9, 1896..	R. W. Hunt & Co.....	250	353.4	9.00	11.43	...	.....	41.0	.....	N. Y. & C. nut coal.
Dilworth Paper Co., New Castle, Pa...	Jan. 14, 1896.	R. B. Day	400	535.8	6.00	10.51	.....	7.3	33.9	.....	Pittsburgh slack.
Armstrong Cork Co., Pittsburgh, Pa..	Jan. 16, 1896.	J. F. Swan.....	250	399.2	3.30	10.54	.....	No test	59.6	.....	N. Y. & C. Run of Mine.
			250	330.9	3.30	11.58	.....	"	32.6	...	" " "
Carrie Furnace Co., Rankin Sta., Pa ...	Jan. 31, 1896.	Pgh. Testing Laboratory	250	318.1	12.00	11.54	1.16	.....	28.5	.....	Blast furnace gas.
Armstrong Cork Co., Pittsburgh, Pa ..	Apr. 22, 1896.	Armstrong Cork Co. ..	250	278.4	9.00	11.14	.....	No test	11.3	.....	Summer Hill nut and slack.
" " " " "	Apr. 23, 1896.	" " " "	250	463.5	9.00	10.85	.....	"	85.4	.....	" " " "
" " " " "	May 4, 1896...	Thos. Pray, Jr	250	257.5	9.00	13.96	.....	40.2	3.0	.....	" " slack.
" " " " "	May 5, 1896...	"	250	416.0	9.00	11.71	.....	26.5	66.4	.....	" " "
Jones & Laughlins, Ld, Pittsburgh, Pa	June 10, 1896.	Jones & Laughlins	250	458.0	8.00	11.09	.....	No test	83.0	.....	Pittsburgh slack and nut.
Traders Paper Co., Lockport, N. Y.....	June 24, 1896.	R. B. Day.....	500	628.0	8.00	12.51	.....	.....	25.6	.....	Bituminous slack and pea coal.
Armstrong Cork Co., Pittsburgh, Pa ..	Aug. 11, 1896.	J. M. Whitham	250	281.5	12.00	11.81	.....	4.3	12.7	.....	N. Y. & C. Sandy Creek.
" " " " "	Aug. 12, 1896.	"	250	501.8	10.00	11.24	.....	4.8	100.7	.....	" " "
Phila. & Read. Coal & Iron Co., Branchdale, Pa.	Sept. 30, 1896.	"	250	230.9	8.25	11.26	.....	3.5	.....	.....	Anthracite culm (55 per ct. combustible.
F. C. Hood, Watertown, Mass.....	Dec. 18, 1896.	Geo. H. Barnes.....	200	209.3	7.00	12.29	.....	5.0	4.5	7.6	Pocahontas.
Merrimack Mfg. Co., Lowell, Mass....	Dec. 31, 1896.	E. F. Miller.....	250	257.6	34.00	11.75	.....	5.17	3.0	.....	George's Creek.
Averages	.....	.....	261	345.0	.....	11.59	.....	.....	32.00	.....	



"FLOWED" STEEL.

It having come to our notice on several occasions recently that some of our competitors in the manufacture of water tube boilers have been offering to the general public Babcock & Wilcox type of boilers, the headers or manifolds and cross-boxes on which are claimed to be made of "flowed" steel, we desire to call your attention to the fact that "flowed" steel is a special mix of open hearth steel manufactured under a secret formula which belongs to us alone, the knowledge of the preparation of which is in the possession of no one except the Penn Steel Casting & Machine Co., of Chester, Pa., and as any one offering either headers, cross-boxes or flanges made of "flowed" steel is doing so with intent to deceive the public, we publish the foregoing statement and, in addition, the accompanying letter written to the Penn Steel Casting & Machine Co. by our general Eastern agents, and their answer to the same.

CAHALL SALES DEPT.

OFFICE OF THAYER & CO., INC., DREXEL BUILDING,
PHILADELPHIA, PA., *January* 21, 1897.

Penn Steel Casting & Machine Co.,
Chester, Pa.

GENTLEMEN: We have information that certain parties are claiming to be able to furnish- in fact, offer to furnish with their boilers—headers and other parts of "flowed" steel.

As "flowed" steel is of a special mixture and our property, we would ask if you have ever furnished or are now furnishing "flowed" steel headers to any party or parties other than ourselves?

An early reply will oblige, Yours truly,

(Signed) THAYER & CO., INC.

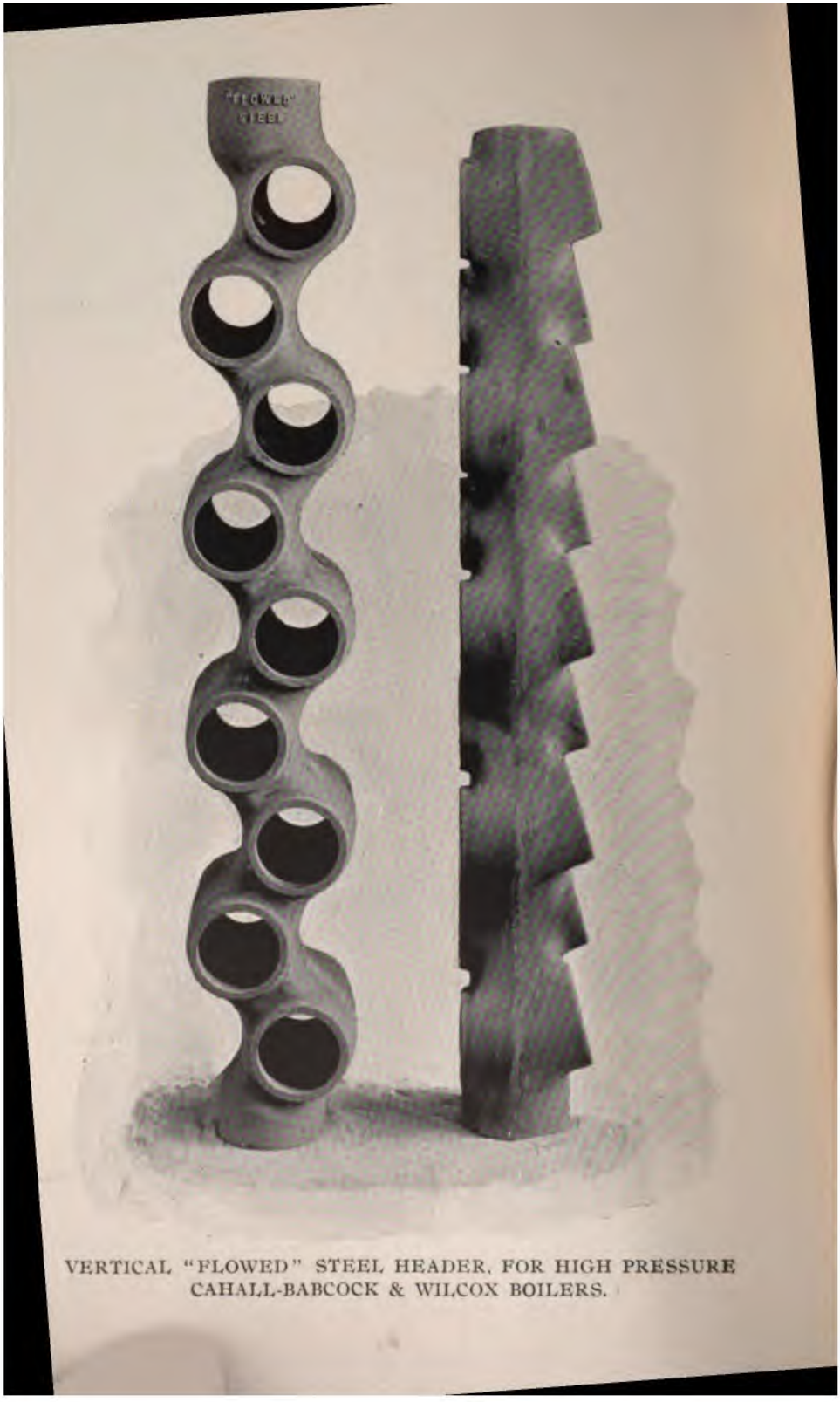
OFFICE OF PENN STEEL CASTING & MACHINE CO.,
CHESTER, PA., *January* 21, 1897.

Messrs. Thayer & Co., Inc.,
Drexel Bldg., Philadelphia.

GENTLEMEN: Referring to your inquiry of even date, we beg to state that we consider the special mixture for flowed steel we are making for you your property, of which you have the sole right, and that we never have nor never will furnish flowed steel to any one but yourselves, unless authorized by you. Neither will we give to any one any information as to the formula mixture of which this special mixture is made.

Yours respectfully,
PENN STEEL CASTING & MACHINE CO.

(Signed) FRED. BALDT, *Manager.*



VERTICAL "FLOWED" STEEL HEADER, FOR HIGH PRESSURE CAHALL-BABCOCK & WILCOX BOILERS.

"FLOWED" STEEL VERTICAL HEADERS FOR CAHALL-BABCOCK & WILCOX BOILERS.

The cuts shown on the opposite page are a special form of header that we have designed, and which we term the Vertical Cahall-Babcock & Wilcox Header. The only object in using a header of this type is to economize space in depth where a horizontal type of boiler is used. A header of this design enables us to install the series of headers at right angles to the steam and water drums overhead, instead of inclining the headers at a considerable angle and making the tubes in the boiler run at right angles to the headers. It is not our intention to furnish this type of header in cast iron at all, but to make it a "Flowed" Steel standard. Boilers constructed in this manner and of this material will not be made for a working pressure of less than 225 pounds to the square inch, and all boilers designed for a working pressure exceeding 225 pounds to the square inch we will build in this way.

Many points of advantage have been claimed by competitors of ours for this vertical type of header, nearly all of which are purely theoretical and are "selling points" mainly. The only valid advantage that can be claimed for this construction under any circumstances is the difference in room occupied, which amounts to about two feet in depth for a 250 H. P. boiler.

For any further information, or for estimates, drawings or particulars of any kind, please address

CAHALL SALES DEPARTMENT,

Bank of Commerce Building, PITTSBURGH, PA.
Perin Building, - - CINCINNATI, O.
Cuyahoga Building, - - CLEVELAND, O.

THAYER & CO., (Inc.,)

GENERAL EASTERN AGENTS,

Tremont Building, - - BOSTON.
Taylor Building - - - NEW YORK.
Drexel Building, - - PHILADELPHIA.

MUNOZ & DARLEY,

GENERAL WESTERN AGENTS,

The Rookery, - - - CHICAGO, ILLS.